

Search for resonant top quark plus jet production in $t\bar{t}$ + jets events with the ATLAS detector in pp collisions at $\sqrt{s} = 7$ TeV

G. Aad *et al.**

(ATLAS Collaboration)

(Received 28 September 2012; published 26 November 2012)

This paper presents a search for a new heavy particle produced in association with a top or antitop quark. Two models in which the new heavy particle is a color singlet or a color triplet are considered, decaying, respectively, to $\bar{t}q$ or tq , leading to a resonance within the $t\bar{t}$ + jets signature. The full 2011 ATLAS pp collision data set from the LHC (4.7 fb^{-1}) is used to search for $t\bar{t}$ events produced in association with jets, in which one of the W bosons from the top quarks decays leptonically and the other decays hadronically. The data are consistent with the Standard Model expectation, and a new particle with mass below 430 GeV for both W' boson and color triplet models is excluded at 95% confidence level, assuming unit right-handed coupling.

DOI: [10.1103/PhysRevD.86.091103](https://doi.org/10.1103/PhysRevD.86.091103)

PACS numbers: 13.85.Rm, 12.60.Cn, 14.65.Ha, 14.70.Pw

In the past few decades, remarkable agreement has been shown between measurements in particle physics and the predictions of the Standard Model (SM). The top quark sector is one important place to look for deviations from the SM, as the large top quark mass suggests that it may play a special role in electroweak symmetry breaking. The recent top quark forward-backward asymmetry measurements from the Tevatron experiments [1,2] are in marginal agreement with SM expectations. A non-SM explanation could come from a possible top-flavor-violating process [3–5]. In these models, a new heavy particle R would be produced at the LHC in association with a top or antitop quark. Figure 1 shows representative production diagrams for these new particles, for the cases of $R = W'$ or $R = \phi$ (see below). As shown in Ref. [6], the production mechanism in pp collisions mainly involves quarks rather than antiquarks at $\sqrt{s} = 7$ TeV, even for relatively low mass particles.

The larger number of quarks relative to antiquarks produced in the initial state at the LHC leads to a resonance R that decays predominantly to either the $t + \text{jet}$ or $\bar{t} + \text{jet}$ final state, where baryon number conservation restricts the models that are available. Two models that can give rise to these final states are a color singlet resonance (W') mostly in the $\bar{t}q$ system, and a di-quark color triplet model with a resonance (ϕ) in the tq system. In both cases a $t\bar{t}$ + jet final state is produced, but a peak will be present in only one of the $t + \text{jet}$ or $\bar{t} + \text{jet}$ invariant mass distributions. The new resonances are assumed not to be self-conjugate, which makes searches for same-sign top quarks insensitive to them [7–9], and to have only right-handed couplings.

*Full author list given at the end of the article.

Published by the American Physical Society under the terms of the [Creative Commons Attribution 3.0 License](https://creativecommons.org/licenses/by/3.0/). Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI.

The t or \bar{t} then decays to W^+b or $W^-\bar{b}$, respectively. This paper considers the decay signature of events in which one W boson decays leptonically (to an electron or muon, plus neutrino final state) and the other W boson decays hadronically. The first direct search for such particles was performed at CDF [10], which excluded color triplet resonances with masses below 200 GeV and W' resonances with masses below 300 GeV, for particles with unit right-handed coupling (g_R) to tq . As is done in this paper, CDF used the formalism in Ref. [3] to define g_R . CMS recently performed a search that excluded a new W' with a mass less than 840 GeV [11] for particles with $g_R = 2$ [12].

The analysis presented here uses the full ATLAS 7 TeV pp collision data set collected in 2011, corresponding to $4.7 \pm 0.2 \text{ fb}^{-1}$ of integrated luminosity [13,14] delivered by the LHC. ATLAS [15] is a multipurpose particle physics detector with cylindrical geometry [16]. The inner detector (ID) system consists of a high-granularity silicon pixel detector and a silicon microstrip detector, as well as a transition radiation straw-tube tracker. The ID is immersed in a 2 T axial magnetic field and provides charged particle tracking in the range $|\eta| < 2.5$. Surrounding the ID, electromagnetic calorimetry is provided by barrel and endcap liquid-argon (LAr)/lead accordion calorimeters and LAr/copper sampling calorimeters in the forward region. Hadronic calorimetry is provided in the barrel by a steel/scintillator tile sampling calorimeter, and in the endcaps and forward region by LAr/copper and LAr/tungsten sampling calorimeters, respectively. The muon spectrometer comprises separate trigger and high-precision tracking chambers measuring the deflection of muons in a magnetic field with a bending power of 2–8 Tm, generated by three superconducting air-core toroid systems. A three-level trigger system is used to select interesting events. The level-1 trigger is implemented in hardware and uses a subset of detector information to reduce the event rate to a design value of at most 75 kHz. This is followed by two

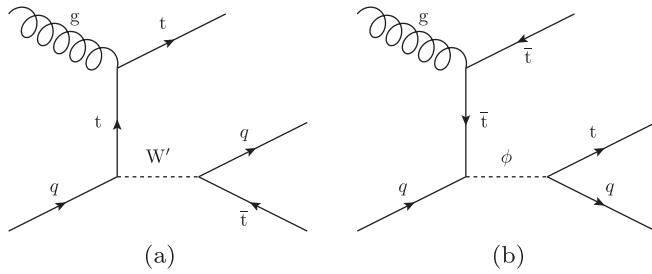


FIG. 1. Example production and decay Feynman diagrams for the (a) W' and (b) ϕ models.

software-based trigger levels, level-2 and the event filter, which together reduce the event rate to ~ 300 Hz.

Events with an electron (muon) are required to have passed an electron (muon) trigger with a threshold of transverse energy $E_T > 20$ GeV (transverse momentum $p_T > 18$ GeV), ensuring that the trigger is fully efficient for the offline selection discussed below. Electrons reconstructed offline are required to have a shower shape in the electromagnetic calorimeter consistent with expectation, as well as a good quality track pointing to the cluster in the calorimeter. Candidate electrons with $E_T > 25$ GeV are required to pass the “tight” electron quality criteria [17], to fall inside a well-instrumented region of the detector ($|\eta| < 2.47$, excluding $1.37 < |\eta| < 1.52$), and to be isolated from other objects in the event. Muons with transverse momentum $p_T > 20$ GeV are required to pass muon quality criteria [18], to be well measured in both the ID and the muon spectrometer, to fall within $|\eta| < 2.5$, and to be isolated from other objects in the event.

Jets are reconstructed in the calorimeter using the anti- k_t [19] algorithm with a radius parameter of 0.4. Jets are required to satisfy $p_T > 25$ GeV and $|\eta| < 2.5$. Events with jets arising from electronic noise bursts and beam backgrounds are rejected [20]. Jets are calibrated to the hadronic energy scale using p_T - and η -dependent corrections derived from simulation, as well as from test-beam and collision data [21]. Jets from the decay of heavy flavor hadrons are selected by a multivariate b -tagging algorithm [22] at an operating point with 70% efficiency for b jets and a mistag rate for light quark jets of less than 1% in simulated $t\bar{t}$ events. Neutrinos are inferred from the magnitude of the missing transverse momentum (E_T^{miss}) in the event [23].

The signal region for this analysis is defined by requiring exactly one charged lepton and five or more jets, including at least one b -tagged jet. To select events with a leptonically decaying W boson, events are required to have $E_T^{\text{miss}} > 30$ GeV ($E_T^{\text{miss}} > 20$ GeV) in the electron (muon) channel. Additionally, the event must have a transverse mass of the leptonically decaying W boson $m_T^W > 30$ GeV in the electron channel, or scalar sum $E_T^{\text{miss}} + m_T^W > 60$ GeV in the muon channel [24]. Here, $(m_T^W)^2 = 2E_T^{\text{miss}}E_T^\ell(1 - \cos\phi)$, where E_T^ℓ is the magnitude of the

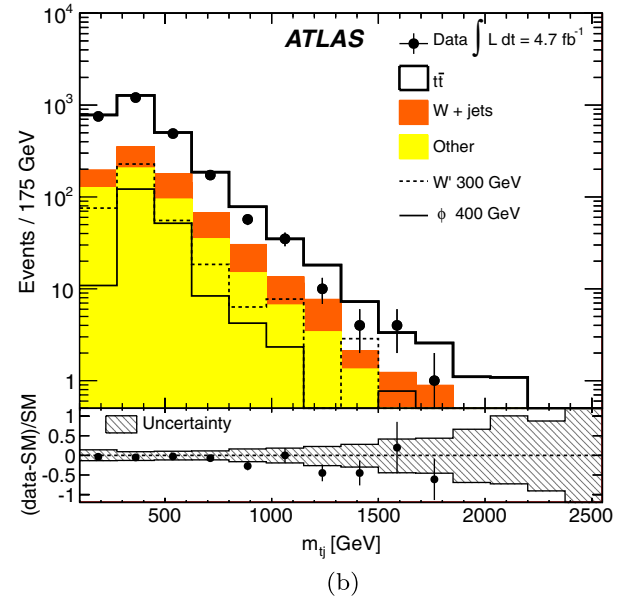
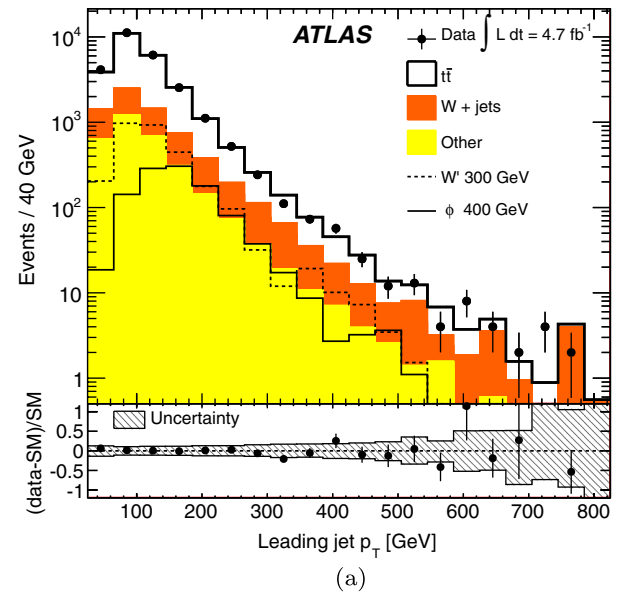


FIG. 2 (color online). The leading jet p_T in the four-jet $t\bar{t}$ control region (a), and m_{ij} in the five-jet $t\bar{t}$ control region (b). The example signal-only distributions are overlaid for comparison, where unit coupling for the new physics process is assumed. The total uncertainty shown on the ratio includes both statistical and systematic effects. The “other” background category includes single top production, diboson production, and multijet events.

transverse momentum of the lepton, and ϕ is the angle between the lepton and the missing transverse momentum in the event.

A variety of Monte Carlo generators are used to study and estimate backgrounds. The generated events are processed through full detector simulation [25], based on GEANT4 [26], and include the effect of multiple pp interactions per bunch crossing. To predict the event yield, the simulation is given an event-by-event weight such that

the distribution of the number of pp collisions matches that in data.

The $t\bar{t}$ background is modeled with MC@NLO v4.01 [27] interfaced to HERWIG v6.520 [28] and JIMMY v4.31 [29]. An additional $t\bar{t}$ sample modeled with MC@NLO interfaced to PYTHIA v6.425 [30] is used to study potential systematic uncertainties. Other $t\bar{t}$ samples use POWHEG [31] interfaced either to PYTHIA or HERWIG, as well as AcerMC v3.8 [32]. The background from the production of single W bosons in association with extra jets is modeled by the ALPGEN v2.13 [33] generator interfaced to HERWIG. The MLM matching scheme [34] is used to form inclusive W boson + jets samples such that overlapping events produced in both the hard scatter and parton showering are removed. In addition, the heavy flavor contributions are reweighted using the data-driven procedures of Ref. [24] using the full 2011 LHC data set. Diboson events are generated using HERWIG. Single-top-quark events are modeled by MC@NLO, interfaced with HERWIG for the parton showering, in the s channel and Wt channel, and by AcerMC v3.8 in the t channel. The small background in which multijet processes are misidentified as prompt leptons is modeled from a data-driven matrix method [35]. In determining the expected event yields, the $t\bar{t}$ cross section is normalized to approximate next-to-next-to-leading-order QCD calculations of 167^{+17}_{-18} pb for a top quark mass of 172.5 GeV [36,37], and the total W + jets background is normalized to inclusive next-to-next-to-leading-order predictions [38]. Signal

events are produced, for a range of W' and ϕ masses, with MadGraph v5.1.3.16 [39] and interfaced to PYTHIA v6.425. Next-to-leading-order (NLO) cross sections are used for the predicted W' boson signal normalization [6], and leading-order (LO) cross sections using MSTW2008 are used for the ϕ -resonance normalization [3].

Events are reconstructed with a kinematic fitting algorithm that utilizes knowledge of the overconstrained $t\bar{t}$ system to assign jets to partons. In the fit, the two top quark masses are each constrained at the particle level to

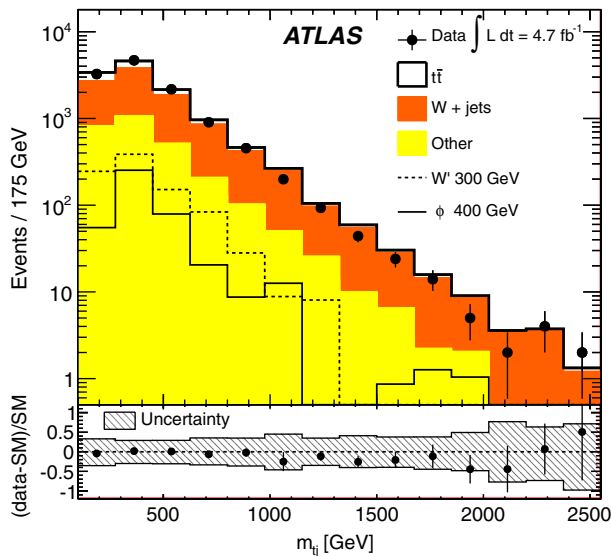


FIG. 3 (color online). Expected and observed distribution of m_{ij} in the W + jets control region. The example signal-only distributions are overlaid for comparison, where unit coupling for the new physics process is assumed. The total uncertainty shown on the ratio includes both statistical and systematic effects. The other background category includes single top production, diboson production, and multijet events.

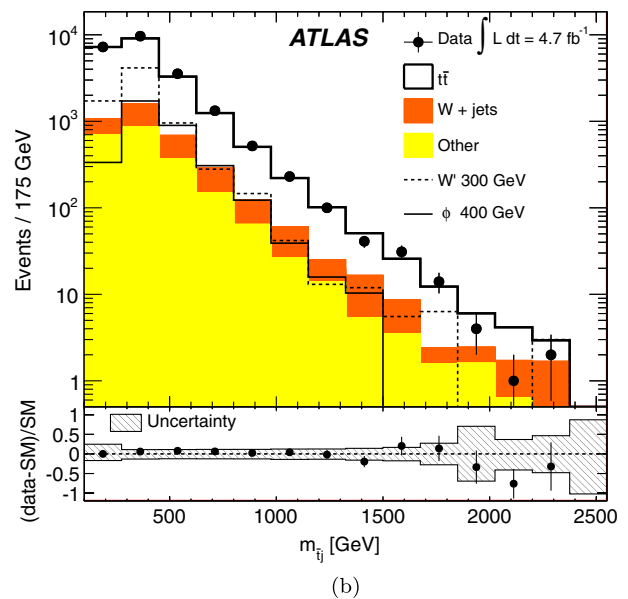
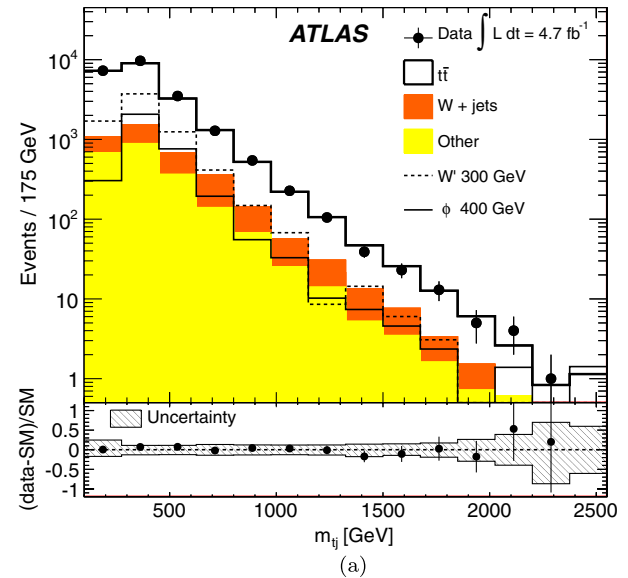


FIG. 4 (color online). Expected and observed distributions of (a) m_{ij} and (b) m_{tj} in the signal region. The example signal distributions assume unit coupling for the new physics process. The total uncertainty shown on the ratio includes both statistical and systematic effects. The other background category includes single top production, diboson production, and multijet events.

TABLE I. Expected and observed yields in the four control regions (CR). Total refers to the total expected background, including $t\bar{t}$, W + jets, and the other smaller backgrounds: single top production, diboson production, and multijet events. The last two lines show the expected number of events for two benchmark signal samples in each of these control regions. The errors include all systematic uncertainties.

	Preselection CR	W + jets CR	Four-jet $t\bar{t}$ CR	Five-jet $t\bar{t}$ CR
$t\bar{t}$	50000 ± 4700	2000 ± 400	19000 ± 600	2100 ± 200
W + jets	46000 ± 14000	7000 ± 2900	3800 ± 800	360 ± 170
Total	116000 ± 21000	12000 ± 3600	26000 ± 1300	2900 ± 440
Observed	110933	11858	26197	2736
300 GeV W'	13900 ± 670	930 ± 110	3000 ± 400	400 ± 80
400 GeV ϕ	6100 ± 200	430 ± 60	1100 ± 100	200 ± 20

172.5 GeV by a penalty in the likelihood, computed from variations from this nominal value and the natural top quark width of 1.5 GeV. The two W boson masses are similarly constrained to 80.4 GeV within a width of 2.1 GeV. This allows the z component of the momentum of the neutrino from the leptonically decaying W boson to be computed. Both solutions from the quadratic ambiguity of this computation are tested when computing the likelihood. Charged lepton, neutrino, and jet four-momenta are constrained in the fit by resolution transfer functions derived from simulated $t\bar{t}$ events that relate the measured momenta in the detector to true particle momenta. The full shapes of these transfer functions are used in the likelihood computation. All assignments of any four jets to partons from the $t\bar{t}$ decay are tested and the assignment with the largest likelihood output for the $t\bar{t}$ hypothesis is selected. After the assignment is selected, the originally measured jet and lepton momenta and E_T^{miss} are used. The remaining jets not associated with the $t\bar{t}$ partons are included to form m_{tj} and $m_{\bar{t}j}$ masses, where the charge of the lepton is used to infer which is the top candidate and which is the antitop candidate. All combinations of extra jets with the top and antitop quark candidates are

considered, and the pairings that give the largest m_{tj} and $m_{\bar{t}j}$ masses are used. In this way, the same extra jet can (but does not necessarily have to) be used to form m_{tj} and $m_{\bar{t}j}$. These two masses are used as observables for the search.

Several control regions are used to ensure good modeling and understanding of the backgrounds before the signal region is examined. The preselection control region requires at least four jets, but does not require a b tag. The dominant $t\bar{t}$ background is tested in a control region with exactly four jets (including at least one b -tagged jet). The rejection of events with more than four jets reduces signal contamination. A second $t\bar{t}$ control region is defined by events with exactly four jets with p_T above 25 GeV, one of which must be b tagged, and exactly one additional jet with p_T between 20 GeV and 25 GeV. Signal contamination is further reduced by requiring that the $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ between the fifth jet and both the reconstructed top and antitop quarks is greater than $\pi/2$. Figure 2 shows distributions in the two $t\bar{t}$ control regions, where good agreement is observed between data and the prediction. The second major background, production of single W bosons in association with extra jets, is tested in a

TABLE II. Expected and observed yields in different signal regions. The errors include all systematic uncertainties. Total refers to the total expected background, including $t\bar{t}$, W + jets, and the other smaller backgrounds: single top production, diboson production, and multijet events, which are not tabulated separately here. Signal window eff. refers to the efficiency for the signal to fall inside the optimized two-dimensional mass window. The signal region yield is calculated in the mass window at each benchmark signal point. Signal σ refers to the total expected signal cross section, not taking into account the t (or \bar{t}) plus jet branching fraction.

	Entire signal region	300 GeV W'	600 GeV W'	400 GeV ϕ	800 GeV ϕ
m_{tj} window [GeV]		$344 < m_{tj} < 494$	$566 < m_{tj} < 904$	$401 < m_{tj} < 455$	$766 < m_{tj} < 819$
$m_{\bar{t}j}$ window [GeV]		$292 < m_{\bar{t}j} < 339$	$549 < m_{\bar{t}j} < 650$	$371 < m_{\bar{t}j} < 608$	$628 < m_{\bar{t}j} < 973$
Signal window eff.		7.5%	9.9%	11.9%	5.7%
$t\bar{t}$	18000 ± 3000	740 ± 160	270 ± 60	660 ± 150	60 ± 10
W + jets	1700 ± 560	60 ± 30	30 ± 20	80 ± 40	8 ± 5
Total	22000 ± 3700	820 ± 190	320 ± 80	780 ± 180	70 ± 20
Observed	22731	970	343	923	77
Signal region yield		560 ± 120	98 ± 24	410 ± 100	20 ± 6
Signal σ		19.0 pb	1.55 pb	7.9 pb	0.67 pb

control region with five or more jets, vetoing events with b -tagged jets. The requirement of zero b -tagged jets reduces both signal and $t\bar{t}$ contamination. The distribution in Fig. 3 shows good agreement between data and the prediction within uncertainties. Table I summarizes the expected and observed yields in the control regions.

Figure 4 shows the expected and observed m_{tj} and $m_{\bar{t}j}$ distributions in the signal region. The data are found to be consistent with the SM expectation. A variety of potential systematic effects are evaluated for the predicted signal and the background rates and shapes. The dominant systematic effects of the jet energy scale [21] and resolution

[40] lead to uncertainties of up to 10% on the total background rate and up to 21% on the total signal expectation, depending on the mass of the new particle. The other dominant systematic uncertainty from the difference in b -tagging efficiency between simulation and data leads to uncertainties of roughly 16% on both the signal and background rates. Effects due to lepton trigger uncertainties and ID efficiency as well as the energy scale and resolution are

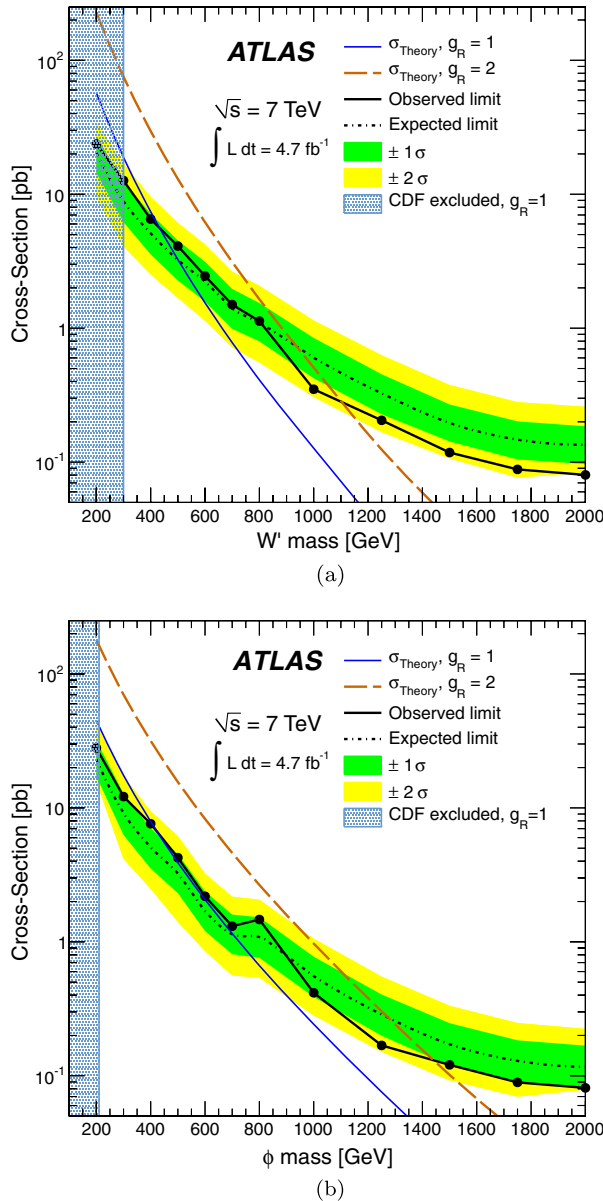


FIG. 5 (color online). Expected and observed 95% C.L. upper limits on the (a) W' and (b) ϕ model cross sections. The CDF result is documented in Ref. [10]. The W' cross sections are NLO calculations, and the ϕ cross sections are LO calculations.

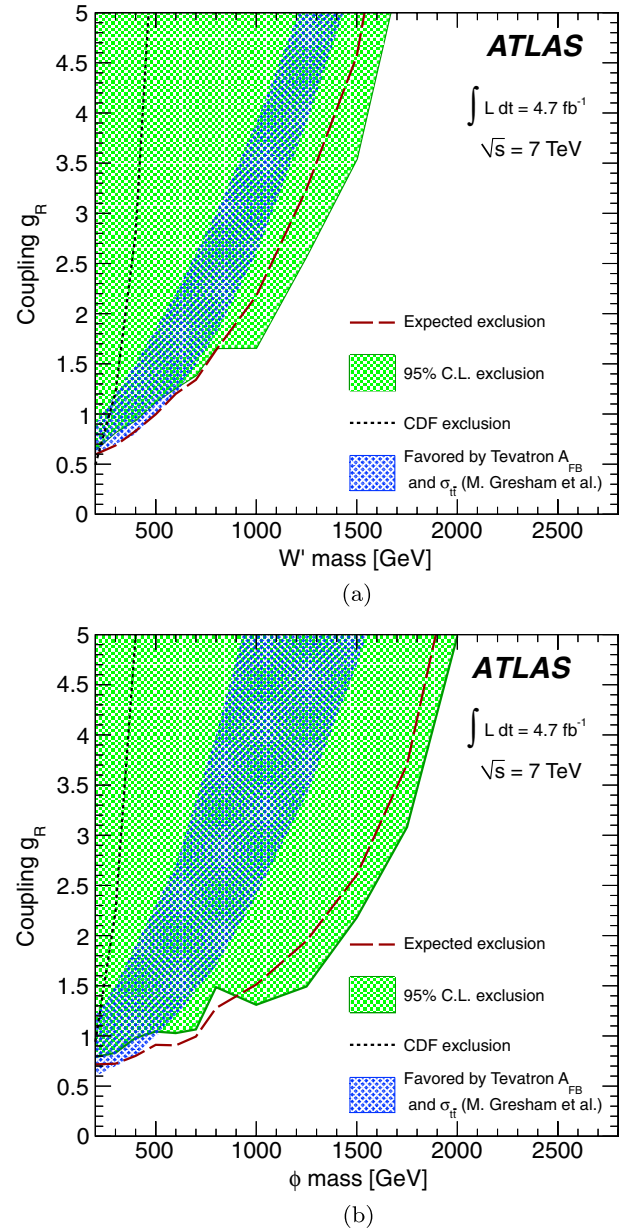


FIG. 6 (color online). Expected and observed 95% C.L. upper limits on the (a) W' and (b) ϕ model cross sections assuming a cross section that scales with g_R^2 . The hatched area shows the region of parameter space excluded by this search at 95% C.L. The CDF result is documented in Ref. [10]. The W' cross sections are NLO calculations, and the ϕ cross sections are LO calculations. The region favored by the Tevatron A_{FB} and $\sigma_{t\bar{t}}$ measurements is shown as the dark band [42].

assessed using $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ data, which lead to systematic uncertainties of a few percent. Other potential systematic effects considered are the size of the small multijet background (assigned 100% uncertainty); $t\bar{t}$ generator uncertainties (evaluated by comparing different results using the MC@NLO and POWHEG generators, 1–10%); $t\bar{t}$ showering and fragmentation uncertainties (evaluated by comparing samples using both PYTHIA and HERWIG, 1%–6%); an uncertainty on the total integrated luminosity (3.9%) [13,14]; and the amount of QCD radiation for the signal and the $t\bar{t}$ background (approximately 10%, evaluated using AcerMC). Total cross section uncertainties of 10% (55%) are used for the $t\bar{t}$ (W + jets) backgrounds.

Expected and observed upper limits on the signal cross section are computed at discrete mass points as follows. For each benchmark signal mass point under consideration, a signal region is defined in the m_{tj} - $m_{\bar{t}j}$ plane. When setting limits for the W' (ϕ) model, the m_{tj} ($m_{\bar{t}j}$) window is significantly wider than the $m_{\bar{t}j}$ (m_{tj}) window to account for the fact that the resonance is predominantly in the $m_{\bar{t}j}$ (m_{tj}) system. The windows are optimized to maximize sensitivity, accounting for the full effect of systematic uncertainties. Typical mass windows are shown in Table II. For each mass window, 95% confidence level (C.L.) upper limits on the signal cross section (times the branching ratio to t or \bar{t}) are computed using a single bin frequentist CL_s method [41]. No shape information is used within the mass windows. Table II shows the expected and observed event yields in several of the signal region windows. Expected and observed 95% C.L. lower limits on the signal mass are derived, assuming a coupling of $g_R = 1$ and $g_R = 2$, and are shown in Fig. 5. Assuming that the cross section scales as g_R^2 , the exclusion in the mass-coupling plane is shown in Fig. 6. As shown, most of the parameter space in this model, which was favored by the Tevatron forward-backward asymmetry and cross section measurements [42], has been excluded.

In conclusion, this paper presents a search for a new heavy particle R in the tj or $\bar{t}j$ system of $t\bar{t}$ plus extra jet events with the ATLAS detector. Such new particles have been proposed as a potential explanation of the difference from the SM values of the forward-backward asymmetries measured in top quark pair production at the Tevatron. The full 2011 ATLAS pp data set (4.7 fb^{-1}) is used in the

search. Assuming unit coupling, the expected 95% C.L. lower limit on the mass of the new particle is 500 (700) GeV in the W' (ϕ) model. No significant excess of data above SM expectation is observed, and 95% C.L. lower limits of 430 GeV for both the W' and ϕ models are set. At $g_R = 2$, the limits are 1.10 (1.45) TeV for the W' (ϕ) model, with expected limits of 0.93 (1.30) TeV. These are the most stringent limits to date on such models. Most of the regions of parameter space for these models that are more consistent with the Tevatron forward-backward asymmetry and $t\bar{t}$ cross section measurements than the SM are excluded at 95% C.L. by these results.

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently. We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWF and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC, and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST, and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR, and VSC CR, Czech Republic; DNRF, DNSRC, and Lundbeck Foundation, Denmark; EPLANET and ERC, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG, and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP, and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTP, Serbia; MSSR, Slovakia; ARRS and MVZT, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF, and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, U.S.A. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular, from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK), and BNL (USA) and in the Tier-2 facilities worldwide.

-
- [1] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. D* **83**, 112003 (2011).
 - [2] V.M. Abazov *et al.* (D0 Collaboration), *Phys. Rev. D* **84**, 112005 (2011).

- [3] K. Zurek, M. Gresham, I.-W. Kim, and K. Zurek, *Phys. Rev. D* **84**, 034025 (2011).
- [4] Y. Cui, Z. Han, and M. D. Schwartz, *J. High Energy Phys.* **07** (2011) 127.

- [5] S. Knapen, Y. Zhao, and M. J. Strassler, *Phys. Rev. D* **86**, 014013 (2012).
- [6] J. Adelman, J. Ferrando, and C. D. White, [arXiv:1206.5731](https://arxiv.org/abs/1206.5731).
- [7] G. Aad *et al.* (ATLAS Collaboration), *J. High Energy Phys.* **04** (2012) 069.
- [8] S. Chatrchyan *et al.* (CMS Collaboration), *Phys. Lett. B* **701**, 204 (2011).
- [9] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **104**, 091801 (2010).
- [10] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **108**, 211805 (2012).
- [11] S. Chatrchyan *et al.* (CMS Collaboration), *Phys. Lett. B* **717**, 351 (2012).
- [12] There are several differences between the models in Refs. [3,4]. The Lagrangian in the former (used in this paper) includes a factor of $1/\sqrt{2}$, and the one in the latter (used by CMS) does not. In addition, Ref. [4] includes additional nonresonant diagrams with cross section that scale as g_R^4 . Such diagrams are not included in Ref. [3].
- [13] ATLAS Collaboration, Report No. ATLAS-CONF-2011-116, <http://cdsweb.cern.ch/record/1376384>.
- [14] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **71**, 1630 (2011).
- [15] G. Aad *et al.* (ATLAS Collaboration), *JINST* **3**, S08003 (2008).
- [16] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the center of the detector and the z axis along the beam pipe. The x axis points from the interaction point to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse (x - y) plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln \tan(\theta/2)$.
- [17] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **72**, 1909 (2012).
- [18] ATLAS Collaboration, Report No. ATLAS-CONF-2011-063, <http://cdsweb.cern.ch/record/1345743>.
- [19] M. Cacciari, G. P. Salam, and G. Soyez, *J. High Energy Phys.* **04** (2008), 063; M. Cacciari and G. P. Salam, *Phys. Lett. B* **641**, 57 (2006).
- [20] ATLAS Collaboration, Report No. ATLAS-CONF-2010-038, <http://cdsweb.cern.ch/record/1277678>.
- [21] ATLAS Collaboration, [arXiv:1112.6426](https://arxiv.org/abs/1112.6426).
- [22] ATLAS Collaboration, Report No. ATLAS-CONF-2012-043, <http://cdsweb.cern.ch/record/1435197>.
- [23] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **72**, 1844 (2012).
- [24] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **72**, 2083 (2012).
- [25] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **70**, 823 (2010).
- [26] S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
- [27] S. Frixione and B. R. Webber, *J. High Energy Phys.* **06** (2002) 029; S. Frixione, P. Nason, and B. R. Webber, *J. High Energy Phys.* **08** (2003) 007.
- [28] G. Corcella, I. G. Knowles, G. Marchesini, S. Moretti, K. Odagiri, P. Richardson, M. H. Seymour, and B. R. Webber, *J. High Energy Phys.* **01** (2001) 010.
- [29] J. Butterworth, J. Forshaw, and M. Seymour, *Z. Phys. C* **72**, 637 (1996).
- [30] T. Sjöstrand, S. Mrenna, and P. Skands, *J. High Energy Phys.* **05** (2006) 026.
- [31] S. Frixione, P. Nason, and C. Oleari, *J. High Energy Phys.* **11** (2007) 070.
- [32] B. Kersevan and E. Richter-Was, *Comput. Phys. Commun.* **149**, 142 (2003).
- [33] M. Mangano, F. Piccinini, A. D. Polosa, M. Moretti, and R. Pittau, *J. High Energy Phys.* **07** (2003) 001.
- [34] S. Hoeche *et al.*, [arXiv:hep-ph/0602031](https://arxiv.org/abs/hep-ph/0602031).
- [35] G. Aad *et al.* (ATLAS Collaboration), *Eur. Phys. J. C* **71**, 1577 (2011).
- [36] S. Moch and P. Uwer, *Phys. Rev. D* **78**, 0034003 (2008).
- [37] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer, and M. Wiedermann, *Comput. Phys. Commun.* **182**, 1034 (2011).
- [38] K. Melnikov and F. Petriello, *Phys. Rev. D* **74**, 114017 (2006).
- [39] J. Alwall, P. Demin, S. de Visscher, R. rederix, M. Herquet, F. Maltoni, T. Plehn, D. L. Rainwater, and T. Stelzer, *J. High Energy Phys.* **09** (2007) 028.
- [40] ATLAS Collaboration, Report No. ATLAS-CONF-2010-054, <http://cdsweb.cern.ch/record/1281311>.
- [41] A. L. Read, *J. Phys. G* **28**, 2693 (2002).
- [42] This region simultaneously satisfies the observed high- $m\bar{t}A_{FB}$, low- $m\bar{t}A_{FB}$, and $\sigma_{\bar{t}\bar{t}}$ observed at the Tevatron. Mathematically it is defined as the region with $\chi^2 < 2.8$, where χ^2 is defined in Eq. (22) in M. Gresham, I.-W. Kim, and K. Zurek, *Phys. Rev. D* **85**, 014022 (2012). The χ^2 for the Standard Model is 2.8.

G. Aad,⁴⁸ T. Abajyan,²¹ B. Abbott,¹¹¹ J. Abdallah,¹² S. Abdel Khalek,¹¹⁵ A. A. Abdelalim,⁴⁹ O. Abdinov,¹¹ R. Aben,¹⁰⁵ B. Abi,¹¹² M. Abolins,⁸⁸ O. S. AbouZeid,¹⁵⁸ H. Abramowicz,¹⁵³ H. Abreu,¹³⁶ E. Acerbi,^{89a,89b} B. S. Acharya,^{164a,164b} L. Adamczyk,³⁸ D. L. Adams,²⁵ T. N. Addy,⁵⁶ J. Adelman,¹⁷⁶ S. Adomeit,⁹⁸ P. Adragna,⁷⁵ T. Adye,¹²⁹ S. Aefsky,²³ J. A. Aguilar-Saavedra,^{124b,b} M. Agustoni,¹⁷ M. Aharrouche,⁸¹ S. P. Ahlen,²² F. Ahles,⁴⁸ A. Ahmad,¹⁴⁸ M. Ahsan,⁴¹ G. Aielli,^{133a,133b} T. Akdogan,^{19a} T. P. A. Åkesson,⁷⁹ G. Akimoto,¹⁵⁵ A. V. Akimov,⁹⁴ M. S. Alam,² M. A. Alam,⁷⁶ J. Albert,¹⁶⁹ S. Albrand,⁵⁵ M. Aleksa,³⁰ I. N. Aleksandrov,⁶⁴ F. Alessandria,^{89a} C. Alexa,^{26a} G. Alexander,¹⁵³ G. Alexandre,⁴⁹ T. Alexopoulos,¹⁰ M. Alhroob,^{164a,164c} M. Aliev,¹⁶ G. Alimonti,^{89a} J. Alison,¹²⁰ B. M. M. Allbrooke,¹⁸ P. P. Allport,⁷³ S. E. Allwood-Spiers,⁵³ J. Almond,⁸² A. Aloisio,^{102a,102b} R. Alon,¹⁷² A. Alonso,⁷⁹ F. Alonso,⁷⁰ B. Alvarez Gonzalez,⁸⁸ M. G. Alviggi,^{102a,102b} K. Amako,⁶⁵ C. Amelung,²³

- V. V. Ammosov,^{128,a} S. P. Amor Dos Santos,^{124a} A. Amorim,^{124a,c} N. Amram,¹⁵³ C. Anastopoulos,³⁰ L. S. Ancu,¹⁷ N. Andari,¹¹⁵ T. Andeen,³⁵ C. F. Anders,^{58b} G. Anders,^{58a} K. J. Anderson,³¹ A. Andreazza,^{89a,89b} V. Andrei,^{58a} X. S. Anduaga,⁷⁰ P. Anger,⁴⁴ A. Angerami,³⁵ F. Anghinolfi,³⁰ A. Anisenkov,¹⁰⁷ N. Anjos,^{124a} A. Annovi,⁴⁷ A. Antonaki,⁹ M. Antonelli,⁴⁷ A. Antonov,⁹⁶ J. Antos,^{144b} F. Anulli,^{132a} M. Aoki,¹⁰¹ S. Aoun,⁸³ L. Aperio Bella,⁵ R. Apolle,^{118,d} G. Arabadze,⁸⁸ I. Aracena,¹⁴³ Y. Arai,⁶⁵ A. T. H. Arce,⁴⁵ S. Arfaoui,¹⁴⁸ J.-F. Arguin,¹⁵ E. Arik,^{19a,a} M. Arik,^{19a} A. J. Armbruster,⁸⁷ O. Arnaez,⁸¹ V. Arnal,⁸⁰ C. Arnault,¹¹⁵ A. Artamonov,⁹⁵ G. Artoni,^{132a,132b} D. Arutinov,²¹ S. Asai,¹⁵⁵ R. Asfandiyarov,¹⁷³ S. Ask,²⁸ B. Åsman,^{146a,146b} L. Asquith,⁶ K. Assamagan,²⁵ A. Astbury,¹⁶⁹ M. Atkinson,¹⁶⁵ B. Aubert,⁵ E. Auge,¹¹⁵ K. Augsten,¹²⁷ M. Aourousseau,^{145a} G. Avolio,¹⁶³ R. Avramidou,¹⁰ D. Axen,¹⁶⁸ G. Azuelos,^{93,e} Y. Azuma,¹⁵⁵ M. A. Baak,³⁰ G. Baccaglioni,^{89a} C. Bacci,^{134a,134b} A. M. Bach,¹⁵ H. Bachacou,¹³⁶ K. Bachas,³⁰ M. Backes,⁴⁹ M. Backhaus,²¹ E. Badescu,^{26a} P. Bagnaia,^{132a,132b} S. Bahinipati,³ Y. Bai,^{33a} D. C. Bailey,¹⁵⁸ T. Bain,¹⁵⁸ J. T. Baines,¹²⁹ O. K. Baker,¹⁷⁶ M. D. Baker,²⁵ S. Baker,⁷⁷ E. Banas,³⁹ P. Banerjee,⁹³ Sw. Banerjee,¹⁷³ D. Banfi,³⁰ A. Bangert,¹⁵⁰ V. Bansal,¹⁶⁹ H. S. Bansil,¹⁸ L. Barak,¹⁷² S. P. Baranov,⁹⁴ A. Barbaro Galtieri,¹⁵ T. Barber,⁴⁸ E. L. Barberio,⁸⁶ D. Barberis,^{50a,50b} M. Barbero,²¹ D. Y. Bardin,⁶⁴ T. Barillari,⁹⁹ M. Barisonzi,¹⁷⁵ T. Barklow,¹⁴³ N. Barlow,²⁸ B. M. Barnett,¹²⁹ R. M. Barnett,¹⁵ A. Baroncelli,^{134a} G. Barone,⁴⁹ A. J. Barr,¹¹⁸ F. Barreiro,⁸⁰ J. Barreiro Guimarães da Costa,⁵⁷ P. Barrillon,¹¹⁵ R. Bartoldus,¹⁴³ A. E. Barton,⁷¹ V. Bartsch,¹⁴⁹ A. Basye,¹⁶⁵ R. L. Bates,⁵³ L. Batkova,^{144a} J. R. Batley,²⁸ A. Battaglia,¹⁷ M. Battistin,³⁰ F. Bauer,¹³⁶ H. S. Bawa,^{143,f} S. Beale,⁹⁸ T. Beau,⁷⁸ P. H. Beauchemin,¹⁶¹ R. Beccherle,^{50a} P. Bechtel,²¹ H. P. Beck,¹⁷ A. K. Becker,¹⁷⁵ S. Becker,⁹⁸ M. Beckingham,¹³⁸ K. H. Becks,¹⁷⁵ A. J. Beddall,^{19c} A. Beddall,^{19c} S. Bedikian,¹⁷⁶ V. A. Bednyakov,⁶⁴ C. P. Bee,⁸³ L. J. Beemster,¹⁰⁵ M. Begel,²⁵ S. Behar Harpaz,¹⁵² P. K. Behera,⁶² M. Beimforde,⁹⁹ C. Belanger-Champagne,⁸⁵ P. J. Bell,⁴⁹ W. H. Bell,⁴⁹ G. Bella,¹⁵³ L. Bellagamba,^{20a} F. Bellina,³⁰ M. Bellomo,³⁰ A. Belloni,⁵⁷ O. Beloborodova,^{107,g} K. Belotskiy,⁹⁶ O. Beltramello,³⁰ O. Benary,¹⁵³ D. Benchebroun,^{135a} K. Bendtz,^{146a,146b} N. Benekos,¹⁶⁵ Y. Benhammou,¹⁵³ E. Benhar Noccioli,⁴⁹ J. A. Benitez Garcia,^{159b} D. P. Benjamin,⁴⁵ M. Benoit,¹¹⁵ J. R. Bensinger,²³ K. Benslama,¹³⁰ S. Bentvelsen,¹⁰⁵ D. Berge,³⁰ E. Bergeas Kuutmann,⁴² N. Berger,⁵ F. Berghaus,¹⁶⁹ E. Berglund,¹⁰⁵ J. Beringer,¹⁵ P. Bernat,⁷⁷ R. Bernhard,⁴⁸ C. Bernius,²⁵ T. Berry,⁷⁶ C. Bertella,⁸³ A. Bertin,^{20a,20b} F. Bertolucci,^{122a,122b} M. I. Besana,^{89a,89b} G. J. Besjes,¹⁰⁴ N. Besson,¹³⁶ S. Bethke,⁹⁹ W. Bhimji,⁴⁶ R. M. Bianchi,³⁰ M. Bianco,^{72a,72b} O. Biebel,⁹⁸ S. P. Bieniek,⁷⁷ K. Bierwagen,⁵⁴ J. Biesiada,¹⁵ M. Biglietti,^{134a} H. Bilokon,⁴⁷ M. Bindi,^{20a,20b} S. Binet,¹¹⁵ A. Bingul,^{19c} C. Bini,^{132a,132b} C. Biscarat,¹⁷⁸ B. Bittner,⁹⁹ K. M. Black,²² R. E. Blair,⁶ J.-B. Blanchard,¹³⁶ G. Blanchot,³⁰ T. Blazek,^{144a} I. Bloch,⁴² C. Blocker,²³ J. Blocki,³⁹ A. Blondel,⁴⁹ W. Blum,⁸¹ U. Blumenschein,⁵⁴ G. J. Bobbink,¹⁰⁵ V. B. Bobrovnikov,¹⁰⁷ S. S. Bocchetta,⁷⁹ A. Bocci,⁴⁵ C. R. Boddy,¹¹⁸ M. Boehler,⁴⁸ J. Boek,¹⁷⁵ N. Boelaert,³⁶ J. A. Bogaerts,³⁰ A. Bogdanchikov,¹⁰⁷ A. Bogouch,^{90,a} C. Bohm,^{146a} J. Bohm,¹²⁵ V. Boisvert,⁷⁶ T. Bold,³⁸ V. Boldea,^{26a} N. M. Bolnet,¹³⁶ M. Bomben,⁷⁸ M. Bona,⁷⁵ M. Boonekamp,¹³⁶ C. N. Booth,¹³⁹ S. Bordini,⁷⁸ C. Borer,¹⁷ A. Borisov,¹²⁸ G. Borissov,⁷¹ I. Borjanovic,^{13a} M. Borri,⁸² S. Borroni,⁸⁷ V. Bortolotto,^{134a,134b} K. Bos,¹⁰⁵ D. Boscherini,^{20a} M. Bosman,¹² H. Boterenbrood,¹⁰⁵ J. Bouchami,⁹³ J. Boudreau,¹²³ E. V. Bouhova-Thacker,⁷¹ D. Boumediene,³⁴ C. Bourdarios,¹¹⁵ N. Bousson,⁸³ A. Boveia,³¹ J. Boyd,³⁰ I. R. Boyko,⁶⁴ I. Bozovic-Jelisavcic,^{13b} J. Bracinik,¹⁸ P. Branchini,^{134a} G. W. Brandenburg,⁵⁷ A. Brandt,⁸ G. Brandt,¹¹⁸ O. Brandt,⁵⁴ U. Bratzler,¹⁵⁶ B. Brau,⁸⁴ J. E. Brau,¹¹⁴ H. M. Braun,^{175,a} S. F. Brazzale,^{164a,164c} B. Brelier,¹⁵⁸ J. Bremer,³⁰ K. Brendlinger,¹²⁰ R. Brenner,¹⁶⁶ S. Bressler,¹⁷² D. Britton,⁵³ F. M. Brochu,²⁸ I. Brock,²¹ R. Brock,⁸⁸ F. Broggi,^{89a} C. Bromberg,⁸⁸ J. Bronner,⁹⁹ G. Brooijmans,³⁵ T. Brooks,⁷⁶ W. K. Brooks,^{32b} G. Brown,⁸² H. Brown,⁸ P. A. Bruckman de Renstrom,³⁹ D. Bruncko,^{144b} R. Bruneliere,⁴⁸ S. Brunet,⁶⁰ A. Bruni,^{20a} G. Bruni,^{20a} M. Bruschi,^{20a} T. Buanes,¹⁴ Q. Buat,⁵⁵ F. Bucci,⁴⁹ J. Buchanan,¹¹⁸ P. Buchholz,¹⁴¹ R. M. Buckingham,¹¹⁸ A. G. Buckley,⁴⁶ S. I. Buda,^{26a} I. A. Budagov,⁶⁴ B. Budick,¹⁰⁸ V. Büscher,⁸¹ L. Bugge,¹¹⁷ O. Bulekov,⁹⁶ A. C. Bundock,⁷³ M. Bunse,⁴³ T. Buran,¹¹⁷ H. Burckhart,³⁰ S. Burdin,⁷³ T. Burgess,¹⁴ S. Burke,¹²⁹ E. Busato,³⁴ P. Bussey,⁵³ C. P. Buszello,¹⁶⁶ B. Butler,¹⁴³ J. M. Butler,²² C. M. Buttar,⁵³ J. M. Butterworth,⁷⁷ W. Buttinger,²⁸ S. Cabrera Urbán,¹⁶⁷ D. Caforio,^{20a,20b} O. Cakir,^{4a} P. Calafiura,¹⁵ G. Calderini,⁷⁸ P. Calfayan,⁹⁸ R. Calkins,¹⁰⁶ L. P. Caloba,^{24a} R. Caloi,^{132a,132b} D. Calvet,³⁴ S. Calvet,³⁴ R. Camacho Toro,³⁴ P. Camarri,^{133a,133b} D. Cameron,¹¹⁷ L. M. Caminada,¹⁵ R. Caminal Armadans,¹² S. Campana,³⁰ M. Campanelli,⁷⁷ V. Canale,^{102a,102b} F. Canelli,^{31,h} A. Canepa,^{159a} J. Cantero,⁸⁰ R. Cantrill,⁷⁶ L. Capasso,^{102a,102b} M. D. M. Capeans Garrido,³⁰ I. Caprini,^{26a} M. Caprini,^{26a} D. Capriotti,⁹⁹ M. Capua,^{37a,37b} R. Caputo,⁸¹ R. Cardarelli,^{133a} T. Carli,³⁰ G. Carlino,^{102a} L. Carminati,^{89a,89b} B. Caron,⁸⁵ S. Caron,¹⁰⁴ E. Carquin,^{32b} G. D. Carrillo Montoya,¹⁷³ A. A. Carter,⁷⁵ J. R. Carter,²⁸ J. Carvalho,^{124a,i} D. Casadei,¹⁰⁸ M. P. Casado,¹² M. Cascella,^{122a,122b} C. Caso,^{50a,50b,a}

- A. M. Castaneda Hernandez,^{173,j} E. Castaneda-Miranda,¹⁷³ V. Castillo Gimenez,¹⁶⁷ N. F. Castro,^{124a} G. Cataldi,^{72a} P. Catastini,⁵⁷ A. Catinaccio,³⁰ J. R. Catmore,³⁰ A. Cattai,³⁰ G. Cattani,^{133a,133b} S. Caughron,⁸⁸ V. Cavaliere,¹⁶⁵ P. Cavalleri,⁷⁸ D. Cavalli,^{89a} M. Cavalli-Sforza,¹² V. Cavasinni,^{122a,122b} F. Ceradini,^{134a,134b} A. S. Cerqueira,^{24b} A. Cerri,³⁰ L. Cerrito,⁷⁵ F. Cerutti,⁴⁷ S. A. Cetin,^{19b} A. Chafaq,^{135a} D. Chakraborty,¹⁰⁶ I. Chalupkova,¹²⁶ K. Chan,³ P. Chang,¹⁶⁵ B. Chapleau,⁸⁵ J. D. Chapman,²⁸ J. W. Chapman,⁸⁷ E. Chareyre,⁷⁸ D. G. Charlton,¹⁸ V. Chavda,⁸² C. A. Chavez Barajas,³⁰ S. Cheatham,⁸⁵ S. Chekanov,⁶ S. V. Chekulaev,^{159a} G. A. Chelkov,⁶⁴ M. A. Chelstowska,¹⁰⁴ C. Chen,⁶³ H. Chen,²⁵ S. Chen,^{33c} X. Chen,¹⁷³ Y. Chen,³⁵ A. Cheplakov,⁶⁴ R. Cherkaoui El Moursli,^{135e} V. Chernyatin,²⁵ E. Cheu,⁷ S. L. Cheung,¹⁵⁸ L. Chevalier,¹³⁶ G. Chiefari,^{102a,102b} L. Chikovani,^{51a,a} J. T. Childers,³⁰ A. Chilingarov,⁷¹ G. Chiodini,^{72a} A. S. Chisholm,¹⁸ R. T. Chislett,⁷⁷ A. Chitan,^{26a} M. V. Chizhov,⁶⁴ G. Choudalakis,³¹ S. Chouridou,¹³⁷ I. A. Christidi,⁷⁷ A. Christov,⁴⁸ D. Chromek-Burckhart,³⁰ M. L. Chu,¹⁵¹ J. Chudoba,¹²⁵ G. Ciapetti,^{132a,132b} A. K. Ciftci,^{4a} R. Ciftci,^{4a} D. Cinca,³⁴ V. Cindro,⁷⁴ C. Ciocca,^{20a,20b} A. Cicio,¹⁵ M. Cirilli,⁸⁷ P. Cirkovic,^{13b} Z. H. Citron,¹⁷² M. Citterio,^{89a} M. Ciubancan,^{26a} A. Clark,⁴⁹ P. J. Clark,⁴⁶ R. N. Clarke,¹⁵ W. Cleland,¹²³ J. C. Clemens,⁸³ B. Clement,⁵⁵ C. Clement,^{146a,146b} Y. Coadou,⁸³ M. Cobal,^{164a,164c} A. Coccaro,¹³⁸ J. Cochran,⁶³ J. G. Cogan,¹⁴³ J. Coggeshall,¹⁶⁵ E. Cogneras,¹⁷⁸ J. Colas,⁵ S. Cole,¹⁰⁶ A. P. Colijn,¹⁰⁵ N. J. Collins,¹⁸ C. Collins-Tooth,⁵³ J. Collot,⁵⁵ T. Colombo,^{119a,119b} G. Colon,⁸⁴ P. Conde Muiño,^{124a} E. Coniavitis,¹¹⁸ M. C. Conidi,¹² S. M. Consonni,^{89a,89b} V. Consorti,⁴⁸ S. Constantinescu,^{26a} C. Conta,^{119a,119b} G. Conti,⁵⁷ F. Conventi,^{102a,k} M. Cooke,¹⁵ B. D. Cooper,⁷⁷ A. M. Cooper-Sarkar,¹¹⁸ K. Copic,¹⁵ T. Cornelissen,¹⁷⁵ M. Corradi,^{20a} F. Corriveau,^{85,l} A. Cortes-Gonzalez,¹⁶⁵ G. Cortiana,⁹⁹ G. Costa,^{89a} M. J. Costa,¹⁶⁷ D. Costanzo,¹³⁹ D. Côté,³⁰ L. Courneyea,¹⁶⁹ G. Cowan,⁷⁶ C. Cowden,²⁸ B. E. Cox,⁸² K. Cranmer,¹⁰⁸ F. Crescioli,^{122a,122b} M. Cristinziani,²¹ G. Crosetti,^{37a,37b} S. Crépé-Renaudin,⁵⁵ C.-M. Cuciuc,^{26a} C. Cuenca Almenar,¹⁷⁶ T. Cuhadar Donszelmann,¹³⁹ M. Curatolo,⁴⁷ C. J. Curtis,¹⁸ C. Cuthbert,¹⁵⁰ P. Cwetanski,⁶⁰ H. Czirr,¹⁴¹ P. Czodrowski,⁴⁴ Z. Czynula,¹⁷⁶ S. D'Auria,⁵³ M. D'Onofrio,⁷³ A. D'Orazio,^{132a,132b} M. J. Da Cunha Sargedas De Sousa,^{124a} C. Da Via,⁸² W. Dabrowski,³⁸ A. Dafinca,¹¹⁸ T. Dai,⁸⁷ C. Dallapiccola,⁸⁴ M. Dam,³⁶ M. Dameri,^{50a,50b} D. S. Damiani,¹³⁷ H. O. Danielsson,³⁰ V. Dao,⁴⁹ G. Darbo,^{50a} G. L. Darlea,^{26b} J. A. Dassoulas,⁴² W. Davey,²¹ T. Davidek,¹²⁶ N. Davidson,⁸⁶ R. Davidson,⁷¹ E. Davies,^{118,d} M. Davies,⁹³ O. Davignon,⁷⁸ A. R. Davison,⁷⁷ Y. Davygora,^{58a} E. Dawe,¹⁴² I. Dawson,¹³⁹ R. K. Daya-Ishmukhametova,²³ K. De,⁸ R. de Asmundis,^{102a} S. De Castro,^{20a,20b} S. De Cecco,⁷⁸ J. de Graat,⁹⁸ N. De Groot,¹⁰⁴ P. de Jong,¹⁰⁵ C. De La Taille,¹¹⁵ H. De la Torre,⁸⁰ F. De Lorenzi,⁶³ L. de Mora,⁷¹ L. De Nooij,¹⁰⁵ D. De Pedis,^{132a} A. De Salvo,^{132a} U. De Sanctis,^{164a,164c} A. De Santo,¹⁴⁹ J. B. De Vivie De Regie,¹¹⁵ G. De Zorzi,^{132a,132b} W. J. Dearnaley,⁷¹ R. Debbé,²⁵ C. Debenedetti,⁴⁶ B. Dechenaux,⁵⁵ D. V. Dedovich,⁶⁴ J. Degenhardt,¹²⁰ C. Del Papa,^{164a,164c} J. Del Peso,⁸⁰ T. Del Prete,^{122a,122b} T. Delemontex,⁵⁵ M. Deliyergiyev,⁷⁴ A. Dell'Acqua,³⁰ L. Dell'Asta,²² M. Della Pietra,^{102a,k} D. della Volpe,^{102a,102b} M. Delmastro,⁵ P. A. Delsart,⁵⁵ C. Deluca,¹⁰⁵ S. Demers,¹⁷⁶ M. Demichev,⁶⁴ B. Demirköz,^{12,m} J. Deng,¹⁶³ S. P. Denisov,¹²⁸ D. Derendarz,³⁹ J. E. Derkaoui,^{135d} F. Derue,⁷⁸ P. Dervan,⁷³ K. Desch,²¹ E. Devetak,¹⁴⁸ P. O. Deviveiros,¹⁰⁵ A. Dewhurst,¹²⁹ B. DeWilde,¹⁴⁸ S. Dhaliwal,¹⁵⁸ R. Dhullipudi,^{25,n} A. Di Ciaccio,^{133a,133b} L. Di Ciaccio,⁵ A. Di Girolamo,³⁰ B. Di Girolamo,³⁰ S. Di Luise,^{134a,134b} A. Di Mattia,¹⁷³ B. Di Micco,³⁰ R. Di Nardo,⁴⁷ A. Di Simone,^{133a,133b} R. Di Sipio,^{20a,20b} M. A. Diaz,^{32a} E. B. Diehl,⁸⁷ J. Dietrich,⁴² T. A. Dietzsch,^{58a} S. Diglio,⁸⁶ K. Dindar Yagci,⁴⁰ J. Dingfelder,²¹ F. Dinut,^{26a} C. Dionisi,^{132a,132b} P. Dita,^{26a} S. Dita,^{26a} F. Dittus,³⁰ F. Djama,⁸³ T. Djobava,^{51b} M. A. B. do Vale,^{24c} A. Do Valle Wemans,^{124a,o} T. K. O. Doan,⁵ M. Dobbs,⁸⁵ R. Dobinson,^{30,a} D. Dobos,³⁰ E. Dobson,^{30,p} J. Dodd,³⁵ C. Doglioni,⁴⁹ T. Doherty,⁵³ Y. Doi,^{65,a} J. Dolejsi,¹²⁶ I. Dolenc,⁷⁴ Z. Dolezal,¹²⁶ B. A. Dolgoshein,^{96,a} T. Dohmae,¹⁵⁵ M. Donadelli,^{24d} J. Donini,³⁴ J. Dopke,³⁰ A. Doria,^{102a} A. Dos Anjos,¹⁷³ A. Dotti,^{122a,122b} M. T. Dova,⁷⁰ A. D. Doxiadis,¹⁰⁵ A. T. Doyle,⁵³ M. Dris,¹⁰ J. Dubbert,⁹⁹ S. Dube,¹⁵ E. Duchovni,¹⁷² G. Duckeck,⁹⁸ D. Duda,¹⁷⁵ A. Dudarev,³⁰ F. Dudziak,⁶³ M. Dührssen,³⁰ I. P. Duerdoth,⁸² L. Duflot,¹¹⁵ M.-A. Dufour,⁸⁵ L. Duguid,⁷⁶ M. Dunford,³⁰ H. Duran Yildiz,^{4a} R. Duxfield,¹³⁹ M. Dwuznik,³⁸ F. Dydak,³⁰ M. Düren,⁵² W. L. Ebenstein,⁴⁵ J. Ebke,⁹⁸ S. Eckweiler,⁸¹ K. Edmonds,⁸¹ W. Edson,² C. A. Edwards,⁷⁶ N. C. Edwards,⁵³ W. Ehrenfeld,⁴² T. Eifert,¹⁴³ G. Eigen,¹⁴ K. Einsweiler,¹⁵ E. Eisenhandler,⁷⁵ T. Ekelof,¹⁶⁶ M. El Kacimi,^{135c} M. Ellert,¹⁶⁶ S. Elles,⁵ F. Ellinghaus,⁸¹ K. Ellis,⁷⁵ N. Ellis,³⁰ J. Elmsheuser,⁹⁸ M. Elsing,³⁰ D. Emelianov,¹²⁹ R. Engelmann,¹⁴⁸ A. Engl,⁹⁸ B. Epp,⁶¹ J. Erdmann,⁵⁴ A. Ereditato,¹⁷ D. Eriksson,^{146a} J. Ernst,² M. Ernst,²⁵ J. Ernwein,¹³⁶ D. Errede,¹⁶⁵ S. Errede,¹⁶⁵ E. Ertel,⁸¹ M. Escalier,¹¹⁵ H. Esch,⁴³ C. Escobar,¹²³ X. Espinal Curull,¹² B. Esposito,⁴⁷ F. Etienne,⁸³ A. I. Etievre,¹³⁶ E. Etzion,¹⁵³ D. Evangelakou,⁵⁴ H. Evans,⁶⁰ L. Fabbri,^{20a,20b} C. Fabre,³⁰ R. M. Fakhruddinov,¹²⁸ S. Falciano,^{132a} Y. Fang,¹⁷³ M. Fanti,^{89a,89b} A. Farbin,⁸ A. Farilla,^{134a} J. Farley,¹⁴⁸ T. Farooque,¹⁵⁸ S. Farrell,¹⁶³ S. M. Farrington,¹⁷⁰ P. Farthouat,³⁰ F. Fassi,¹⁶⁷

- P. Fassnacht,³⁰ D. Fassouliotis,⁹ B. Fathollahzadeh,¹⁵⁸ A. Favareto,^{89a,89b} L. Fayard,¹¹⁵ S. Fazio,^{37a,37b} R. Febbraro,³⁴ P. Federic,^{144a} O. L. Fedin,¹²¹ W. Fedorko,⁸⁸ M. Fehling-Kaschek,⁴⁸ L. Feligioni,⁸³ D. Fellmann,⁶ C. Feng,^{33d} E. J. Feng,⁶ A. B. Fenyuk,¹²⁸ J. Ferencei,^{144b} W. Fernando,⁶ S. Ferrag,⁵³ J. Ferrando,⁵³ V. Ferrara,⁴² A. Ferrari,¹⁶⁶ P. Ferrari,¹⁰⁵ R. Ferrari,^{119a} D. E. Ferreira de Lima,⁵³ A. Ferrer,¹⁶⁷ D. Ferrere,⁴⁹ C. Ferretti,⁸⁷ A. Ferretto Parodi,^{50a,50b} M. Fiascaris,³¹ F. Fiedler,⁸¹ A. Filipčič,⁷⁴ F. Filthaut,¹⁰⁴ M. Fincke-Keeler,¹⁶⁹ M. C. N. Fiolhais,^{124a,i} L. Fiorini,¹⁶⁷ A. Firan,⁴⁰ G. Fischer,⁴² M. J. Fisher,¹⁰⁹ M. Flechl,⁴⁸ I. Fleck,¹⁴¹ J. Fleckner,⁸¹ P. Fleischmann,¹⁷⁴ S. Fleischmann,¹⁷⁵ T. Flick,¹⁷⁵ A. Floderus,⁷⁹ L. R. Flores Castillo,¹⁷³ M. J. Flowerdew,⁹⁹ T. Fonseca Martin,¹⁷ A. Formica,¹³⁶ A. Forti,⁸² D. Fortin,^{159a} D. Fournier,¹¹⁵ A. J. Fowler,⁴⁵ H. Fox,⁷¹ P. Francavilla,¹² M. Franchini,^{20a,20b} S. Franchino,^{119a,119b} D. Francis,³⁰ T. Frank,¹⁷² S. Franz,³⁰ M. Fraternali,^{119a,119b} S. Fratina,¹²⁰ S. T. French,²⁸ C. Friedrich,⁴² F. Friedrich,⁴⁴ R. Froeschl,³⁰ D. Froidevaux,³⁰ J. A. Frost,²⁸ C. Fukunaga,¹⁵⁶ E. Fullana Torregrosa,³⁰ B. G. Fulsom,¹⁴³ J. Fuster,¹⁶⁷ C. Gabaldon,³⁰ O. Gabizon,¹⁷² T. Gadfort,²⁵ S. Gadomski,⁴⁹ G. Gagliardi,^{50a,50b} P. Gagnon,⁶⁰ C. Galea,⁹⁸ B. Galhardo,^{124a} E. J. Gallas,¹¹⁸ V. Gallo,¹⁷ B. J. Gallop,¹²⁹ P. Gallus,¹²⁵ K. K. Gan,¹⁰⁹ Y. S. Gao,^{143,f} A. Gaponenko,¹⁵ F. Garbersen,¹⁷⁶ M. Garcia-Sciveres,¹⁵ C. García,¹⁶⁷ J. E. García Navarro,¹⁶⁷ R. W. Gardner,³¹ N. Garelli,³⁰ H. Garitaonandia,¹⁰⁵ V. Garonne,³⁰ C. Gatti,⁴⁷ G. Gaudio,^{119a} B. Gaur,¹⁴¹ L. Gauthier,¹³⁶ P. Gauzzi,^{132a,132b} I. L. Gavrilenko,⁹⁴ C. Gay,¹⁶⁸ G. Gaycken,²¹ E. N. Gazis,¹⁰ P. Ge,^{33d} Z. Gecse,¹⁶⁸ C. N. P. Gee,¹²⁹ D. A. A. Geerts,¹⁰⁵ Ch. Geich-Gimbel,²¹ K. Gellerstedt,^{146a,146b} C. Gemme,^{50a} A. Gemmell,⁵³ M. H. Genest,⁵⁵ S. Gentile,^{132a,132b} M. George,⁵⁴ S. George,⁷⁶ P. Gerlach,¹⁷⁵ A. Gershon,¹⁵³ C. Geweniger,^{58a} H. Ghazlane,^{135b} N. Ghodbane,³⁴ B. Giacobbe,^{20a} S. Giagu,^{132a,132b} V. Giakoumopoulou,⁹ V. Giangiobbe,¹² F. Gianotti,³⁰ B. Gibbard,²⁵ A. Gibson,¹⁵⁸ S. M. Gibson,³⁰ D. Gillberg,²⁹ A. R. Gillman,¹²⁹ D. M. Gingrich,^{3,e} J. Ginzburg,¹⁵³ N. Giokaris,⁹ M. P. Giordani,^{164c} R. Giordano,^{102a,102b} F. M. Giorgi,¹⁶ P. Giovannini,⁹⁹ P. F. Giraud,¹³⁶ D. Giugni,^{89a} M. Giunta,⁹³ P. Giusti,^{20a} B. K. Gjelsten,¹¹⁷ L. K. Gladilin,⁹⁷ C. Glasman,⁸⁰ J. Glatzer,⁴⁸ A. Glazov,⁴² K. W. Glitza,¹⁷⁵ G. L. Glonti,⁶⁴ J. R. Goddard,⁷⁵ J. Godfrey,¹⁴² J. Godlewski,³⁰ M. Goebel,⁴² T. Göpfert,⁴⁴ C. Goeringer,⁸¹ C. Gössling,⁴³ S. Goldfarb,⁸⁷ T. Golling,¹⁷⁶ A. Gomes,^{124a,c} L. S. Gomez Fajardo,⁴² R. Gonçalves,⁷⁶ J. Goncalves Pinto Firmino Da Costa,⁴² L. Gonella,²¹ S. Gonzalez,¹⁷³ S. González de la Hoz,¹⁶⁷ G. Gonzalez Parra,¹² M. L. Gonzalez Silva,²⁷ S. Gonzalez-Sevilla,⁴⁹ J. J. Goodson,¹⁴⁸ L. Goossens,³⁰ P. A. Gorbounov,⁹⁵ H. A. Gordon,²⁵ I. Gorelov,¹⁰³ G. Gorfine,¹⁷⁵ B. Gorini,³⁰ E. Gorini,^{72a,72b} A. Gorišek,⁷⁴ E. Gornicki,³⁹ B. Gosdzik,⁴² A. T. Goshaw,⁶ M. Gosselink,¹⁰⁵ M. I. Gostkin,⁶⁴ I. Gough Eschrich,¹⁶³ M. Goughri,^{135a} D. Goudami,^{135c} M. P. Goulette,⁴⁹ A. G. Goussiou,¹³⁸ C. Goy,⁵ S. Gozpinar,²³ I. Grabowska-Bold,³⁸ P. Grafström,^{20a,20b} K.-J. Grahn,⁴² F. Grancagnolo,^{72a} S. Grancagnolo,¹⁶ V. Grassi,¹⁴⁸ V. Gratchev,¹²¹ N. Grau,³⁵ H. M. Gray,³⁰ J. A. Gray,¹⁴⁸ E. Graziani,^{134a} O. G. Grebenyuk,¹²¹ T. Greenshaw,⁷³ Z. D. Greenwood,^{25,n} K. Gregersen,³⁶ I. M. Gregor,⁴² P. Grenier,¹⁴³ J. Griffiths,⁸ N. Grigalashvili,⁶⁴ A. A. Grillo,¹³⁷ S. Grinstein,¹² Ph. Gris,³⁴ Y. V. Grishkevich,⁹⁷ J.-F. Grivaz,¹¹⁵ E. Gross,¹⁷² J. Grosse-Knetter,⁵⁴ J. Groth-Jensen,¹⁷² K. Grybel,¹⁴¹ D. Guest,¹⁷⁶ C. Guicheney,³⁴ S. Guindon,⁵⁴ U. Gul,⁵³ H. Guler,^{85,q} J. Gunther,¹²⁵ B. Guo,¹⁵⁸ J. Guo,³⁵ P. Gutierrez,¹¹¹ N. Guttman,¹⁵³ O. Gutzwiller,¹⁷³ C. Guyot,¹³⁶ C. Gwenlan,¹¹⁸ C. B. Gwilliam,⁷³ A. Haas,¹⁴³ S. Haas,³⁰ C. Haber,¹⁵ H. K. Hadavand,⁴⁰ D. R. Hadley,¹⁸ P. Haefner,²¹ F. Hahn,³⁰ S. Haider,³⁰ Z. Hajduk,³⁹ H. Hakobyan,¹⁷⁷ D. Hall,¹¹⁸ J. Haller,⁵⁴ K. Hamacher,¹⁷⁵ P. Hamal,¹¹³ M. Hamer,⁵⁴ A. Hamilton,^{145b,r} S. Hamilton,¹⁶¹ L. Han,^{33b} K. Hanagaki,¹¹⁶ K. Hanawa,¹⁶⁰ M. Hance,¹⁵ C. Handel,⁸¹ P. Hanke,^{58a} J. R. Hansen,³⁶ J. B. Hansen,³⁶ J. D. Hansen,³⁶ P. H. Hansen,³⁶ P. Hansson,¹⁴³ K. Hara,¹⁶⁰ G. A. Hare,¹³⁷ T. Harenberg,¹⁷⁵ S. Harkusha,⁹⁰ D. Harper,⁸⁷ R. D. Harrington,⁴⁶ O. M. Harris,¹³⁸ J. Hartert,⁴⁸ F. Hartjes,¹⁰⁵ T. Haruyama,⁶⁵ A. Harvey,⁵⁶ S. Hasegawa,¹⁰¹ Y. Hasegawa,¹⁴⁰ S. Hassani,¹³⁶ S. Haug,¹⁷ M. Hauschild,³⁰ R. Hauser,⁸⁸ M. Havranek,²¹ C. M. Hawkes,¹⁸ R. J. Hawkins,³⁰ A. D. Hawkins,⁷⁹ D. Hawkins,¹⁶³ T. Hayakawa,⁶⁶ T. Hayashi,¹⁶⁰ D. Hayden,⁷⁶ C. P. Hays,¹¹⁸ H. S. Hayward,⁷³ S. J. Haywood,¹²⁹ S. J. Head,¹⁸ V. Hedberg,⁷⁹ L. Heelan,⁸ S. Heim,⁸⁸ B. Heinemann,¹⁵ S. Heisterkamp,³⁶ L. Helary,²² C. Heller,⁹⁸ M. Heller,³⁰ S. Hellman,^{146a,146b} D. Hellmich,²¹ C. Helsens,¹² R. C. W. Henderson,⁷¹ M. Henke,^{58a} A. Henrichs,⁵⁴ A. M. Henriques Correia,³⁰ S. Henrot-Versille,¹¹⁵ C. Hensel,⁵⁴ T. Henß,¹⁷⁵ C. M. Hernandez,⁸ Y. Hernández Jiménez,¹⁶⁷ R. Herrberg,¹⁶ G. Herten,⁴⁸ R. Hertenberger,⁹⁸ L. Hervas,³⁰ G. G. Hesketh,⁷⁷ N. P. Hessey,¹⁰⁵ E. Higón-Rodríguez,¹⁶⁷ J. C. Hill,²⁸ K. H. Hiller,⁴² S. Hillert,²¹ S. J. Hillier,¹⁸ I. Hinchliffe,¹⁵ E. Hines,¹²⁰ M. Hirose,¹¹⁶ F. Hirsch,⁴³ D. Hirschbuehl,¹⁷⁵ J. Hobbs,¹⁴⁸ N. Hod,¹⁵³ M. C. Hodgkinson,¹³⁹ P. Hodgson,¹³⁹ A. Hoecker,³⁰ M. R. Hoefkamp,¹⁰³ J. Hoffman,⁴⁰ D. Hoffmann,⁸³ M. Hohlfield,⁸¹ M. Holder,¹⁴¹ S. O. Holmgren,^{146a} T. Holy,¹²⁷ J. L. Holzbauer,⁸⁸ T. M. Hong,¹²⁰ L. Hooft van Huysduynen,¹⁰⁸ S. Horner,⁴⁸ J.-Y. Hostachy,⁵⁵ S. Hou,¹⁵¹ A. Hoummada,^{135a} J. Howard,¹¹⁸ J. Howarth,⁸² I. Hristova,¹⁶ J. Hrivnac,¹¹⁵ T. Hryn'ova,⁵ P. J. Hsu,⁸¹ S.-C. Hsu,¹⁵ D. Hu,³⁵ Z. Hubacek,¹²⁷ F. Hubaut,⁸³

- F. Huegging,²¹ A. Huettmann,⁴² T. B. Huffman,¹¹⁸ E. W. Hughes,³⁵ G. Hughes,⁷¹ M. Huhtinen,³⁰ M. Hurwitz,¹⁵ U. Husemann,⁴² N. Huseynov,^{64,s} J. Huston,⁸⁸ J. Huth,⁵⁷ G. Iacobucci,⁴⁹ G. Iakovidis,¹⁰ M. Ibbotson,⁸² I. Ibragimov,¹⁴¹ L. Iconomidou-Fayard,¹¹⁵ J. Idarraga,¹¹⁵ P. Iengo,^{102a} O. Igonkina,¹⁰⁵ Y. Ikegami,⁶⁵ M. Ikeno,⁶⁵ D. Iliadis,¹⁵⁴ N. Ilic,¹⁵⁸ T. Ince,²¹ J. Inigo-Golfín,³⁰ P. Ioannou,⁹ M. Iodice,^{134a} K. Iordanidou,⁹ V. Ippolito,^{132a,132b} A. Irles Quiles,¹⁶⁷ C. Isaksson,¹⁶⁶ M. Ishino,⁶⁷ M. Ishitsuka,¹⁵⁷ R. Ishmukhametov,⁴⁰ C. Issever,¹¹⁸ S. Istin,^{19a} A. V. Ivashin,¹²⁸ W. Iwanski,³⁹ H. Iwasaki,⁶⁵ J. M. Izen,⁴¹ V. Izzo,^{102a} B. Jackson,¹²⁰ J. N. Jackson,⁷³ P. Jackson,¹ M. R. Jaekel,³⁰ V. Jain,⁶⁰ K. Jakobs,⁴⁸ S. Jakobsen,³⁶ T. Jakoubek,¹²⁵ J. Jakubek,¹²⁷ D. K. Jana,¹¹¹ E. Jansen,⁷⁷ H. Jansen,³⁰ A. Jantsch,⁹⁹ M. Janus,⁴⁸ G. Jarlskog,⁷⁹ L. Jeanty,⁵⁷ I. Jen-La Plante,³¹ D. Jennens,⁸⁶ P. Jenni,³⁰ A. E. Loevschall-Jensen,³⁶ P. Jež,³⁶ S. Jézéquel,⁵ M. K. Jha,^{20a} H. Ji,¹⁷³ W. Ji,⁸¹ J. Jia,¹⁴⁸ Y. Jiang,^{33b} M. Jimenez Belenguer,⁴² S. Jin,^{33a} O. Jinnouchi,¹⁵⁷ M. D. Joergensen,³⁶ D. Joffe,⁴⁰ M. Johansen,^{146a,146b} K. E. Johansson,^{146a} P. Johansson,¹³⁹ S. Johnert,⁴² K. A. Johns,⁷ K. Jon-And,^{146a,146b} G. Jones,¹⁷⁰ R. W. L. Jones,⁷¹ T. J. Jones,⁷³ C. Joram,³⁰ P. M. Jorge,^{124a} K. D. Joshi,⁸² J. Jovicevic,¹⁴⁷ T. Jovin,^{13b} X. Ju,¹⁷³ C. A. Jung,⁴³ R. M. Jungst,³⁰ V. Juranek,¹²⁵ P. Jussel,⁶¹ A. Juste Rozas,¹² S. Kabana,¹⁷ M. Kaci,¹⁶⁷ A. Kaczmarska,³⁹ P. Kadlecik,³⁶ M. Kado,¹¹⁵ H. Kagan,¹⁰⁹ M. Kagan,⁵⁷ E. Kajomovitz,¹⁵² S. Kalinin,¹⁷⁵ L. V. Kalinovskaya,⁶⁴ S. Kama,⁴⁰ N. Kanaya,¹⁵⁵ M. Kaneda,³⁰ S. Kaneti,²⁸ T. Kanno,¹⁵⁷ V. A. Kantserov,⁹⁶ J. Kanzaki,⁶⁵ B. Kaplan,¹⁰⁸ A. Kapliy,³¹ J. Kaplon,³⁰ D. Kar,⁵³ M. Karagounis,²¹ K. Karakostas,¹⁰ M. Karnevskiy,⁴² V. Kartvelishvili,⁷¹ A. N. Karyukhin,¹²⁸ L. Kashif,¹⁷³ G. Kasieczka,^{58b} R. D. Kass,¹⁰⁹ A. Kastanas,¹⁴ M. Kataoka,⁵ Y. Kataoka,¹⁵⁵ E. Katsoufis,¹⁰ J. Katzy,⁴² V. Kaushik,⁷ K. Kawagoe,⁶⁹ T. Kawamoto,¹⁵⁵ G. Kawamura,⁸¹ M. S. Kayl,¹⁰⁵ S. Kazama,¹⁵⁵ V. A. Kazanin,¹⁰⁷ M. Y. Kazarinov,⁶⁴ R. Keeler,¹⁶⁹ P. T. Keener,¹²⁰ R. Kehoe,⁴⁰ M. Keil,⁵⁴ G. D. Kekelidze,⁶⁴ J. S. Keller,¹³⁸ M. Kenyon,⁵³ O. Kepka,¹²⁵ N. Kerschen,³⁰ B. P. Kerševan,⁷⁴ S. Kersten,¹⁷⁵ K. Kessoku,¹⁵⁵ J. Keung,¹⁵⁸ F. Khalil-zada,¹¹ H. Khandanyan,^{146a,146b} A. Khanov,¹¹² D. Kharchenko,⁶⁴ A. Khodinov,⁹⁶ A. Khomich,^{58a} T. J. Khoo,²⁸ G. Khorauli,²¹ A. Khoroshilov,¹⁷⁵ V. Khovanskiy,⁹⁵ E. Khramov,⁶⁴ J. Khubua,^{51b} H. Kim,^{146a,146b} S. H. Kim,¹⁶⁰ N. Kimura,¹⁷¹ O. Kind,¹⁶ B. T. King,⁷³ M. King,⁶⁶ R. S. B. King,¹¹⁸ J. Kirk,¹²⁹ A. E. Kiryunin,⁹⁹ T. Kishimoto,⁶⁶ D. Kisieleska,³⁸ T. Kitamura,⁶⁶ T. Kittelmann,¹²³ K. Kiuchi,¹⁶⁰ E. Kladiya,^{144b} M. Klein,⁷³ U. Klein,⁷³ K. Kleinknecht,⁸¹ M. Klemetti,⁸⁵ A. Klier,¹⁷² P. Klimek,^{146a,146b} A. Klimentov,²⁵ R. Klingenberg,⁴³ J. A. Klinger,⁸² E. B. Klinkby,³⁶ T. Klioutchnikova,³⁰ P. F. Klok,¹⁰⁴ S. Klous,¹⁰⁵ E.-E. Kluge,^{58a} T. Kluge,⁷³ P. Kluit,¹⁰⁵ S. Kluth,⁹⁹ N. S. Knecht,¹⁵⁸ E. Kneringer,⁶¹ E. B. F. G. Knoop,⁸³ A. Knue,⁵⁴ B. R. Ko,⁴⁵ T. Kobayashi,¹⁵⁵ M. Kobel,⁴⁴ M. Kocian,¹⁴³ P. Kodys,¹²⁶ K. Köneke,³⁰ A. C. König,¹⁰⁴ S. Koenig,⁸¹ L. Köpke,⁸¹ F. Koetsveld,¹⁰⁴ P. Koevesarki,²¹ T. Koffas,²⁹ E. Koffeman,¹⁰⁵ L. A. Kogan,¹¹⁸ S. Kohlmann,¹⁷⁵ F. Kohn,⁵⁴ Z. Kohout,¹²⁷ T. Kohriki,⁶⁵ T. Koi,¹⁴³ G. M. Kolachev,^{107,a} H. Kolanoski,¹⁶ V. Kolesnikov,⁶⁴ I. Koletsou,^{89a} J. Koll,⁸⁸ M. Kollefrath,⁴⁸ A. A. Komar,⁹⁴ Y. Komori,¹⁵⁵ T. Kondo,⁶⁵ T. Kono,^{42,t} A. I. Kononov,⁴⁸ R. Konoplich,^{108,u} N. Konstantinidis,⁷⁷ S. Koperny,³⁸ K. Korcyl,³⁹ K. Kordas,¹⁵⁴ A. Korn,¹¹⁸ A. Korol,¹⁰⁷ I. Korolkov,¹² E. V. Korolkova,¹³⁹ V. A. Korotkov,¹²⁸ O. Kortner,⁹⁹ S. Kortner,⁹⁹ V. V. Kostyukhin,²¹ S. Kotov,⁹⁹ V. M. Kotov,⁶⁴ A. Kotwal,⁴⁵ C. Kourkoumelis,⁹ V. Kouskoura,¹⁵⁴ A. Koutsman,^{159a} R. Kowalewski,¹⁶⁹ T. Z. Kowalski,³⁸ W. Kozanecki,¹³⁶ A. S. Kozhin,¹²⁸ V. Kral,¹²⁷ V. A. Kramarenko,⁹⁷ G. Kramberger,⁷⁴ M. W. Krasny,⁷⁸ A. Krasznahorkay,¹⁰⁸ J. K. Kraus,²¹ S. Kreiss,¹⁰⁸ F. Krejci,¹²⁷ J. Kretzschmar,⁷³ N. Krieger,⁵⁴ P. Krieger,¹⁵⁸ K. Kroeninger,⁵⁴ H. Kroha,⁹⁹ J. Kroll,¹²⁰ J. Kroseberg,²¹ J. Krstic,^{13a} U. Kruchonak,⁶⁴ H. Krüger,²¹ T. Kruker,¹⁷ N. Krumnack,⁶³ Z. V. Krumshteyn,⁶⁴ T. Kubota,⁸⁶ S. Kuday,^{4a} S. Kuehn,⁴⁸ A. Kugel,^{58c} T. Kuhl,⁴² D. Kuhn,⁶¹ V. Kukhtin,⁶⁴ Y. Kulchitsky,⁹⁰ S. Kuleshov,^{32b} C. Kummer,⁹⁸ M. Kuna,⁷⁸ J. Kunkle,¹²⁰ A. Kupco,¹²⁵ H. Kurashige,⁶⁶ M. Kurata,¹⁶⁰ Y. A. Kurochkin,⁹⁰ V. Kus,¹²⁵ E. S. Kuwertz,¹⁴⁷ M. Kuze,¹⁵⁷ J. Kvita,¹⁴² R. Kwee,¹⁶ A. La Rosa,⁴⁹ L. La Rotonda,^{37a,37b} L. Labarga,⁸⁰ J. Labbe,⁵ S. Lablak,^{135a} C. Lacasta,¹⁶⁷ F. Lacava,^{132a,132b} H. Lacker,¹⁶ D. Lacour,⁷⁸ V. R. Lacuesta,¹⁶⁷ E. Ladygin,⁶⁴ R. Lafaye,⁵ B. Laforge,⁷⁸ T. Lagouri,¹⁷⁶ S. Lai,⁴⁸ E. Laisne,⁵⁵ M. Lamanna,³⁰ L. Lambourne,⁷⁷ C. L. Lampen,⁷ W. Lampl,⁷ E. Lancon,¹³⁶ U. Landgraf,⁴⁸ M. P. J. Landon,⁷⁵ J. L. Lane,⁸² V. S. Lang,^{58a} C. Lange,⁴² A. J. Lankford,¹⁶³ F. Lanni,²⁵ K. Lantzsch,¹⁷⁵ S. Laplace,⁷⁸ C. Lapoire,²¹ J. F. Laporte,¹³⁶ T. Lari,^{89a} A. Larner,¹¹⁸ M. Lassnig,³⁰ P. Laurelli,⁴⁷ V. Lavorini,^{37a,37b} W. Lavrijsen,¹⁵ P. Laycock,⁷³ O. Le Dortz,⁷⁸ E. Le Guirriec,⁸³ C. Le Maner,¹⁵⁸ E. Le Menedeu,¹² T. LeCompte,⁶ F. Ledroit-Guillon,⁵⁵ H. Lee,¹⁰⁵ J. S. H. Lee,¹¹⁶ S. C. Lee,¹⁵¹ L. Lee,¹⁷⁶ M. Lefebvre,¹⁶⁹ M. Legendre,¹³⁶ F. Legger,⁹⁸ C. Leggett,¹⁵ M. Lehmacher,²¹ G. Lehmann Miotto,³⁰ X. Lei,⁷ M. A. L. Leite,^{24d} R. Leitner,¹²⁶ D. Lellouch,¹⁷² B. Lemmer,⁵⁴ V. Lendermann,^{58a} K. J. C. Leney,^{145b} T. Lenz,¹⁰⁵ G. Lenzen,¹⁷⁵ B. Lenzi,³⁰ K. Leonhardt,⁴⁴ S. Leontsinis,¹⁰ F. Lepold,^{58a} C. Leroy,⁹³ J.-R. Lessard,¹⁶⁹ C. G. Lester,²⁸ C. M. Lester,¹²⁰ J. Levêque,⁵ D. Levin,⁸⁷ L. J. Levinson,¹⁷² A. Lewis,¹¹⁸ G. H. Lewis,¹⁰⁸ A. M. Leyko,²¹ M. Leyton,¹⁶ B. Li,⁸³ H. Li,^{173,v} S. Li,^{33b,w} X. Li,⁸⁷ Z. Liang,^{118,x} H. Liao,³⁴

- B. Liberti,^{133a} P. Lichard,³⁰ M. Lichtnecker,⁹⁸ K. Lie,¹⁶⁵ W. Liebig,¹⁴ C. Limbach,²¹ A. Limosani,⁸⁶ M. Limper,⁶² S. C. Lin,^{151,y} F. Linde,¹⁰⁵ J. T. Linnemann,⁸⁸ E. Lipeles,¹²⁰ A. Lipniacka,¹⁴ T. M. Liss,¹⁶⁵ D. Lissauer,²⁵ A. Lister,⁴⁹ A. M. Litke,¹³⁷ C. Liu,²⁹ D. Liu,¹⁵¹ H. Liu,⁸⁷ J. B. Liu,⁸⁷ L. Liu,⁸⁷ M. Liu,^{33b} Y. Liu,^{33b} M. Livan,^{119a,119b} S. S. A. Livermore,¹¹⁸ A. Lleres,⁵⁵ J. Llorente Merino,⁸⁰ S. L. Lloyd,⁷⁵ E. Lobodzinska,⁴² P. Loch,⁷ W. S. Lockman,¹³⁷ T. Loddenkoetter,²¹ F. K. Loebinger,⁸² A. Loginov,¹⁷⁶ C. W. Loh,¹⁶⁸ T. Lohse,¹⁶ K. Lohwasser,⁴⁸ M. Lokajicek,¹²⁵ V. P. Lombardo,⁵ R. E. Long,⁷¹ L. Lopes,^{124a} D. Lopez Mateos,⁵⁷ J. Lorenz,⁹⁸ N. Lorenzo Martinez,¹¹⁵ M. Losada,¹⁶² P. Loscutoff,¹⁵ F. Lo Sterzo,^{132a,132b} M. J. Losty,^{159a} X. Lou,⁴¹ A. Lounis,¹¹⁵ K. F. Loureiro,¹⁶² J. Love,⁶ P. A. Love,⁷¹ A. J. Lowe,^{143,f} F. Lu,^{33a} H. J. Lubatti,¹³⁸ C. Luci,^{132a,132b} A. Lucotte,⁵⁵ A. Ludwig,⁴⁴ D. Ludwig,⁴² I. Ludwig,⁴⁸ J. Ludwig,⁴⁸ F. Luehring,⁶⁰ G. Luijckx,¹⁰⁵ W. Lukas,⁶¹ D. Lumb,⁴⁸ L. Luminari,^{132a} E. Lund,¹¹⁷ B. Lund-Jensen,¹⁴⁷ B. Lundberg,⁷⁹ J. Lundberg,^{146a,146b} O. Lundberg,^{146a,146b} J. Lundquist,³⁶ M. Lungwitz,⁸¹ D. Lynn,²⁵ E. Lytken,⁷⁹ H. Ma,²⁵ L. L. Ma,¹⁷³ G. Maccarrone,⁴⁷ A. Macchiolo,⁹⁹ B. Maček,⁷⁴ J. Machado Miguens,^{124a} R. Mackeprang,³⁶ R. J. Madaras,¹⁵ H. J. Maddocks,⁷¹ W. F. Mader,⁴⁴ R. Maenner,^{58c} T. Maeno,²⁵ P. Mättig,¹⁷⁵ S. Mättig,⁸¹ L. Magnoni,¹⁶³ E. Magradze,⁵⁴ K. Mahboubi,⁴⁸ J. Mahlstedt,¹⁰⁵ S. Mahmoud,⁷³ G. Mahout,¹⁸ C. Maiani,¹³⁶ C. Maidantchik,^{24a} A. Maio,^{124a,c} S. Majewski,²⁵ Y. Makida,⁶⁵ N. Makovec,¹¹⁵ P. Mal,¹³⁶ B. Malaescu,³⁰ Pa. Malecki,³⁹ P. Malecki,³⁹ V. P. Maleev,¹²¹ F. Malek,⁵⁵ U. Mallik,⁶² D. Malon,⁶ C. Malone,¹⁴³ S. Maltezos,¹⁰ V. Malyshev,¹⁰⁷ S. Malyukov,³⁰ R. Mameghani,⁹⁸ J. Mamuzic,^{13b} A. Manabe,⁶⁵ L. Mandelli,^{89a} I. Mandić,⁷⁴ R. Mandrysch,¹⁶ J. Maneira,^{124a} A. Manfredini,⁹⁹ P. S. Mangeard,⁸⁸ L. Manhaes de Andrade Filho,^{24b} J. A. Manjarres Ramos,¹³⁶ A. Mann,⁵⁴ P. M. Manning,¹³⁷ A. Manousakis-Katsikakis,⁹ B. Mansoulie,¹³⁶ A. Mapelli,³⁰ L. Mapelli,³⁰ L. March,⁸⁰ J. F. Marchand,²⁹ F. Marchese,^{133a,133b} G. Marchiori,⁷⁸ M. Marcisovsky,¹²⁵ C. P. Marino,¹⁶⁹ F. Marroquim,^{24a} Z. Marshall,³⁰ F. K. Martens,¹⁵⁸ L. F. Marti,¹⁷ S. Marti-Garcia,¹⁶⁷ B. Martin,³⁰ B. Martin,⁸⁸ J. P. Martin,⁹³ T. A. Martin,¹⁸ V. J. Martin,⁴⁶ B. Martin dit Latour,⁴⁹ S. Martin-Haugh,¹⁴⁹ M. Martinez,¹² V. Martinez Outschoorn,⁵⁷ A. C. Martyniuk,¹⁶⁹ M. Marx,⁸² F. Marzano,^{132a} A. Marzin,¹¹¹ L. Masetti,⁸¹ T. Mashimo,¹⁵⁵ R. Mashinistov,⁹⁴ J. Masik,⁸² A. L. Maslennikov,¹⁰⁷ I. Massa,^{20a,20b} G. Massaro,¹⁰⁵ N. Massol,⁵ P. Mastrandrea,¹⁴⁸ A. Mastroberardino,^{37a,37b} T. Masubuchi,¹⁵⁵ P. Matricon,¹¹⁵ H. Matsunaga,¹⁵⁵ T. Matsushita,⁶⁶ C. Mattravers,^{118,d} J. Maurer,⁸³ S. J. Maxfield,⁷³ A. Mayne,¹³⁹ R. Mazini,¹⁵¹ M. Mazur,²¹ L. Mazzaferro,^{133a,133b} M. Mazzanti,^{89a} J. Mc Donald,⁸⁵ S. P. Mc Kee,⁸⁷ A. McCarn,¹⁶⁵ R. L. McCarthy,¹⁴⁸ T. G. McCarthy,²⁹ N. A. McCubbin,¹²⁹ K. W. McFarlane,^{56,a} J. A. Mcfayden,¹³⁹ G. Mchedlize,^{51b} T. McLaughlan,¹⁸ S. J. McMahon,¹²⁹ R. A. McPherson,^{169,i} A. Meade,⁸⁴ J. Mechnich,¹⁰⁵ M. Mechtel,¹⁷⁵ M. Medinnis,⁴² R. Meera-Lebbai,¹¹¹ T. Meguro,¹¹⁶ R. Mehdiyev,⁹³ S. Mehlhase,³⁶ A. Mehta,⁷³ K. Meier,^{58a} B. Meirose,⁷⁹ C. Melachrinou,³¹ B. R. Mellado Garcia,¹⁷³ F. Meloni,^{89a,89b} L. Mendoza Navas,¹⁶² Z. Meng,^{151,v} A. Mengarelli,^{20a,20b} S. Menke,⁹⁹ E. Meoni,¹⁶¹ K. M. Mercurio,⁵⁷ P. Mermod,⁴⁹ L. Merola,^{102a,102b} C. Meroni,^{89a} F. S. Merritt,³¹ H. Merritt,¹⁰⁹ A. Messina,^{30,z} J. Metcalfe,²⁵ A. S. Mete,¹⁶³ C. Meyer,⁸¹ C. Meyer,³¹ J-P. Meyer,¹³⁶ J. Meyer,¹⁷⁴ J. Meyer,⁵⁴ T. C. Meyer,³⁰ J. Miao,^{33d} S. Michal,³⁰ L. Micu,^{26a} R. P. Middleton,¹²⁹ S. Migas,⁷³ L. Mijović,¹³⁶ G. Mikenberg,¹⁷² M. Mikestikova,¹²⁵ M. Mikuž,⁷⁴ D. W. Miller,³¹ R. J. Miller,⁸⁸ W. J. Mills,¹⁶⁸ C. Mills,⁵⁷ A. Milov,¹⁷² D. A. Milstead,^{146a,146b} D. Milstein,¹⁷² A. A. Minaenko,¹²⁸ M. Miñano Moya,¹⁶⁷ I. A. Minashvili,⁶⁴ A. I. Mincer,¹⁰⁸ B. Mindur,³⁸ M. Mineev,⁶⁴ Y. Ming,¹⁷³ L. M. Mir,¹² G. Mirabelli,^{132a} J. Mitrevski,¹³⁷ V. A. Mitsou,¹⁶⁷ S. Mitsui,⁶⁵ P. S. Miyagawa,¹³⁹ J. U. Mjörnmark,⁷⁹ T. Moa,^{146a,146b} V. Moeller,²⁸ K. Mönig,⁴² N. Möser,²¹ S. Mohapatra,¹⁴⁸ W. Mohr,⁴⁸ R. Moles-Valls,¹⁶⁷ A. Molfetas,³⁰ J. Monk,⁷⁷ E. Monnier,⁸³ J. Montejo Berlingen,¹² F. Monticelli,⁷⁰ S. Monzani,^{20a,20b} R. W. Moore,³ G. F. Moorhead,⁸⁶ C. Mora Herrera,⁴⁹ A. Moraes,⁵³ N. Morange,¹³⁶ J. Morel,⁵⁴ G. Morello,^{37a,37b} D. Moreno,⁸¹ M. Moreno Llácer,¹⁶⁷ P. Morettini,^{50a} M. Morgenstern,⁴⁴ M. Morii,⁵⁷ A. K. Morley,³⁰ G. Mornacchi,³⁰ J. D. Morris,⁷⁵ L. Morvaj,¹⁰¹ H. G. Moser,⁹⁹ M. Mosidze,^{51b} J. Moss,¹⁰⁹ R. Mount,¹⁴³ E. Mountricha,^{10,aa} S. V. Mouraviev,^{94,a} E. J. W. Moyse,⁸⁴ F. Mueller,^{58a} J. Mueller,¹²³ K. Mueller,²¹ T. A. Müller,⁹⁸ T. Mueller,⁸¹ D. Muenstermann,³⁰ Y. Munwes,¹⁵³ W. J. Murray,¹²⁹ I. Mussche,¹⁰⁵ E. Musto,^{102a,102b} A. G. Myagkov,¹²⁸ M. Myska,¹²⁵ J. Nadal,¹² K. Nagai,¹⁶⁰ R. Nagai,¹⁵⁷ K. Nagano,⁶⁵ A. Nagarkar,¹⁰⁹ Y. Nagasaka,⁵⁹ M. Nagel,⁹⁹ A. M. Nairz,³⁰ Y. Nakahama,³⁰ K. Nakamura,¹⁵⁵ T. Nakamura,¹⁵⁵ I. Nakano,¹¹⁰ G. Nanava,²¹ A. Napier,¹⁶¹ R. Narayan,^{58b} M. Nash,^{77,d} T. Nattermann,²¹ T. Naumann,⁴² G. Navarro,¹⁶² H. A. Neal,⁸⁷ P. Yu. Nechaeva,⁹⁴ T. J. Neep,⁸² A. Negri,^{119a,119b} G. Negri,³⁰ M. Negrini,^{20a} S. Nektarijevic,⁴⁹ A. Nelson,¹⁶³ T. K. Nelson,¹⁴³ S. Nemecek,¹²⁵ P. Nemethy,¹⁰⁸ A. A. Nepomuceno,^{24a} M. Nessi,^{30,bb} M. S. Neubauer,¹⁶⁵ M. Neumann,¹⁷⁵ A. Neusiedl,⁸¹ R. M. Neves,¹⁰⁸ P. Nevski,²⁵ F. M. Newcomer,¹²⁰ P. R. Newman,¹⁸ V. Nguyen Thi Hong,¹³⁶ R. B. Nickerson,¹¹⁸ R. Nicolaïdou,¹³⁶ B. Nicquevert,³⁰ F. Niedercorn,¹¹⁵ J. Nielsen,¹³⁷

- N. Nikiforou,³⁵ A. Nikiforov,¹⁶ V. Nikolaenko,¹²⁸ I. Nikolic-Audit,⁷⁸ K. Nikolics,⁴⁹ K. Nikolopoulos,¹⁸ H. Nilsen,⁴⁸ P. Nilsson,⁸ Y. Ninomiya,¹⁵⁵ A. Nisati,^{132a} R. Nisius,⁹⁹ T. Nobe,¹⁵⁷ L. Nodulman,⁶ M. Nomachi,¹¹⁶ I. Nomidis,¹⁵⁴ S. Norberg,¹¹¹ M. Nordberg,³⁰ P. R. Norton,¹²⁹ J. Novakova,¹²⁶ M. Nozaki,⁶⁵ L. Nozka,¹¹³ I. M. Nugent,^{159a} A.-E. Nuncio-Quiroz,²¹ G. Nunes Hanninger,⁸⁶ T. Nunnemann,⁹⁸ E. Nurse,⁷⁷ B. J. O'Brien,⁴⁶ S. W. O'Neale,^{18,a} D. C. O'Neil,¹⁴² V. O'Shea,⁵³ L. B. Oakes,⁹⁸ F. G. Oakham,^{29,e} H. Oberlack,⁹⁹ J. Ocariz,⁷⁸ A. Ochi,⁶⁶ S. Oda,⁶⁹ S. Odaka,⁶⁵ J. Odier,⁸³ H. Ogren,⁶⁰ A. Oh,⁸² S. H. Oh,⁴⁵ C. C. Ohm,³⁰ T. Ohshima,¹⁰¹ H. Okawa,²⁵ Y. Okumura,³¹ T. Okuyama,¹⁵⁵ A. Olariu,^{26a} A. G. Olchevski,⁶⁴ S. A. Olivares Pino,^{32a} M. Oliveira,^{124a,i} D. Oliveira Damazio,²⁵ E. Oliver Garcia,¹⁶⁷ D. Olivito,¹²⁰ A. Olszewski,³⁹ J. Olszowska,³⁹ A. Onofre,^{124a,cc} P. U. E. Onyisi,³¹ C. J. Oram,^{159a} M. J. Oreglia,³¹ Y. Oren,¹⁵³ D. Orestano,^{134a,134b} N. Orlando,^{72a,72b} I. Orlov,¹⁰⁷ C. Oropeza Barrera,⁵³ R. S. Orr,¹⁵⁸ B. Osculati,^{50a,50b} R. Ospanov,¹²⁰ C. Osuna,¹² G. Otero y Garzon,²⁷ J. P. Ottersbach,¹⁰⁵ M. Ouchrif,^{135d} E. A. Ouellette,¹⁶⁹ F. Ould-Saada,¹¹⁷ A. Ouraou,¹³⁶ Q. Ouyang,^{33a} A. Ovcharova,¹⁵ M. Owen,⁸² S. Owen,¹³⁹ V. E. Ozcan,^{19a} N. Ozturk,⁸ A. Pacheco Pages,¹² C. Padilla Aranda,¹² S. Pagan Griso,¹⁵ E. Paganis,¹³⁹ C. Pahl,⁹⁹ F. Paige,²⁵ P. Pais,⁸⁴ K. Pajchel,¹¹⁷ G. Palacino,^{159b} C. P. Paelari,⁷ S. Palestini,³⁰ D. Pallin,³⁴ A. Palma,^{124a} J. D. Palmer,¹⁸ Y. B. Pan,¹⁷³ E. Panagiotopoulou,¹⁰ P. Pani,¹⁰⁵ N. Panikashvili,⁸⁷ S. Panitkin,²⁵ D. Pantea,^{26a} A. Papadelis,^{146a} Th. D. Papadopoulou,¹⁰ A. Paramonov,⁶ D. Paredes Hernandez,³⁴ W. Park,^{25,dd} M. A. Parker,²⁸ F. Parodi,^{50a,50b} J. A. Parsons,³⁵ U. Parzefall,⁴⁸ S. Pashapour,⁵⁴ E. Pasqualucci,^{132a} S. Passaggio,^{50a} A. Passeri,^{134a} F. Pastore,^{134a,134b,a} Fr. Pastore,⁷⁶ G. Pásztor,^{49,ee} S. Patariaia,¹⁷⁵ N. Patel,¹⁵⁰ J. R. Pater,⁸² S. Patricelli,^{102a,102b} T. Pauly,³⁰ M. Pecsny,^{144a} S. Pedraza Lopez,¹⁶⁷ M. I. Pedraza Morales,¹⁷³ S. V. Peleganchuk,¹⁰⁷ D. Pelikan,¹⁶⁶ H. Peng,^{33b} B. Penning,³¹ A. Penson,³⁵ J. Penwell,⁶⁰ M. Perantoni,^{24a} K. Perez,^{35,ff} T. Perez Cavalcanti,⁴² E. Perez Codina,^{159a} M. T. Pérez García-Estañ,¹⁶⁷ V. Perez Reale,³⁵ L. Perini,^{89a,89b} H. Pernegger,³⁰ R. Perrino,^{72a} P. Perrodo,⁵ V. D. Peshekhonov,⁶⁴ K. Peters,³⁰ B. A. Petersen,³⁰ J. Petersen,³⁰ T. C. Petersen,³⁶ E. Petit,⁵ A. Petridis,¹⁵⁴ C. Petridou,¹⁵⁴ E. Petrollo,^{132a} F. Petrucci,^{134a,134b} D. Petschull,⁴² M. Petteni,¹⁴² R. Pezoa,^{32b} A. Phan,⁸⁶ P. W. Phillips,¹²⁹ G. Piacquadio,³⁰ A. Picazio,⁴⁹ E. Piccaro,⁷⁵ M. Piccinini,^{20a,20b} S. M. Picc,⁴² R. Piegai,²⁷ D. T. Pignotti,¹⁰⁹ J. E. Pilcher,³¹ A. D. Pilkington,⁸² J. Pina,^{124a,c} M. Pinamonti,^{164a,164c} A. Pinder,¹¹⁸ J. L. Pinfold,³ B. Pinto,^{124a} C. Pizio,^{89a,89b} M. Plamondon,¹⁶⁹ M.-A. Pleier,²⁵ E. Plotnikova,⁶⁴ A. Poblaguev,²⁵ S. Poddar,^{58a} F. Podlyski,³⁴ L. Poggioli,¹¹⁵ D. Pohl,²¹ M. Pohl,⁴⁹ G. Polesello,^{119a} A. Policicchio,^{37a,37b} A. Polini,^{20a} J. Poll,⁷⁵ V. Polychronakos,²⁵ D. Pomeroy,²³ K. Pommès,³⁰ L. Pontecorvo,^{132a} B. G. Pope,⁸⁸ G. A. Popeneciu,^{26a} D. S. Popovic,^{13a} A. Poppleton,³⁰ X. Portell Bueso,³⁰ G. E. Pospelov,⁹⁹ S. Pospisil,¹²⁷ I. N. Potrap,⁹⁹ C. J. Potter,¹⁴⁹ C. T. Potter,¹¹⁴ G. Poulard,³⁰ J. Poveda,⁶⁰ V. Pozdnyakov,⁶⁴ R. Prabhu,⁷⁷ P. Pralavorio,⁸³ A. Pranko,¹⁵ S. Prasad,³⁰ R. Pravahan,²⁵ S. Prell,⁶³ K. Pretzl,¹⁷ D. Price,⁶⁰ J. Price,⁷³ L. E. Price,⁶ D. Prieur,¹²³ M. Primavera,^{72a} K. Prokofiev,¹⁰⁸ F. Prokoshin,^{32b} S. Protopopescu,²⁵ J. Proudfoot,⁶ X. Prudent,⁴⁴ M. Przybycien,³⁸ H. Przysieznik,⁵ S. Psoroulas,²¹ E. Ptacek,¹¹⁴ E. Pueschel,⁸⁴ J. Purdham,⁸⁷ M. Purohit,^{25,dd} P. Puzo,¹¹⁵ Y. Pylypchenko,⁶² J. Qian,⁸⁷ A. Quadt,⁵⁴ D. R. Quarrie,¹⁵ W. B. Quayle,¹⁷³ F. Quinonez,^{32a} M. Raas,¹⁰⁴ V. Radeka,²⁵ V. Radescu,⁴² P. Radloff,¹¹⁴ T. Rador,^{19a} F. Ragusa,^{89a,89b} G. Rahal,¹⁷⁸ A. M. Rahimi,¹⁰⁹ D. Rahm,²⁵ S. Rajagopalan,²⁵ M. Rammensee,⁴⁸ M. Rammes,¹⁴¹ A. S. Randle-Conde,⁴⁰ K. Randrianarivony,²⁹ F. Rauscher,⁹⁸ T. C. Rave,⁴⁸ M. Raymond,³⁰ A. L. Read,¹¹⁷ D. M. Rebuzzi,^{119a,119b} A. Redelbach,¹⁷⁴ G. Redlinger,²⁵ R. Reece,¹²⁰ K. Reeves,⁴¹ E. Reinherz-Aronis,¹⁵³ A. Reinsch,¹¹⁴ I. Reisinger,⁴³ C. Rembser,³⁰ Z. L. Ren,¹⁵¹ A. Renaud,¹¹⁵ M. Rescigno,^{132a} S. Resconi,^{89a} B. Resende,¹³⁶ P. Reznicek,⁹⁸ R. Rezvani,¹⁵⁸ R. Richter,⁹⁹ E. Richter-Was,^{5,gg} M. Ridel,⁷⁸ M. Rijpsstra,¹⁰⁵ M. Rijssenbeek,¹⁴⁸ A. Rimoldi,^{119a,119b} L. Rinaldi,^{20a} R. R. Rios,⁴⁰ I. Riu,¹² G. Rivoltella,^{89a,89b} F. Rizatdinova,¹¹² E. Rizvi,⁷⁵ S. H. Robertson,^{85,i} A. Robichaud-Veronneau,¹¹⁸ D. Robinson,²⁸ J. E. M. Robinson,⁸² A. Robson,⁵³ J. G. Rocha de Lima,¹⁰⁶ C. Roda,^{122a,122b} D. Roda Dos Santos,³⁰ A. Roe,⁵⁴ S. Roe,³⁰ O. Røhne,¹¹⁷ S. Rolli,¹⁶¹ A. Romaniouk,⁹⁶ M. Romano,^{20a,20b} G. Romeo,²⁷ E. Romero Adam,¹⁶⁷ N. Rompotis,¹³⁸ L. Roos,⁷⁸ E. Ros,¹⁶⁷ S. Rosati,^{132a} K. Rosbach,⁴⁹ A. Rose,¹⁴⁹ M. Rose,⁷⁶ G. A. Rosenbaum,¹⁵⁸ E. I. Rosenberg,⁶³ P. L. Rosendahl,¹⁴ O. Rosenthal,¹⁴¹ L. Rossetti,⁴⁹ V. Rossetti,¹² E. Rossi,^{132a,132b} L. P. Rossi,^{50a} M. Rotaru,^{26a} I. Roth,¹⁷² J. Rothberg,¹³⁸ D. Rousseau,¹¹⁵ C. R. Royon,¹³⁶ A. Rozanov,⁸³ Y. Rozen,¹⁵² X. Ruan,^{33a,hh} F. Rubbo,¹² I. Rubinskiy,⁴² N. Ruckstuhl,¹⁰⁵ V. I. Rud,⁹⁷ C. Rudolph,⁴⁴ G. Rudolph,⁶¹ F. Rühr,⁷ A. Ruiz-Martinez,⁶³ L. Rumyantsev,⁶⁴ Z. Rurikova,⁴⁸ N. A. Rusakovich,⁶⁴ J. P. Rutherford,⁷ C. Ruwiedel,^{15,a} P. Ruzicka,¹²⁵ Y. F. Ryabov,¹²¹ M. Rybar,¹²⁶ G. Rybkin,¹¹⁵ N. C. Ryder,¹¹⁸ A. F. Saavedra,¹⁵⁰ I. Sadeh,¹⁵³ H. F.-W. Sadrozinski,¹³⁷ R. Sadykov,⁶⁴ F. Safai Tehrani,^{132a} H. Sakamoto,¹⁵⁵ G. Salamanna,⁷⁵ A. Salamon,^{133a} M. Saleem,¹¹¹ D. Salek,³⁰ D. Salihagic,⁹⁹ A. Salnikov,¹⁴³ J. Salt,¹⁶⁷ B. M. Salvachua Ferrando,⁶ D. Salvatore,^{37a,37b} F. Salvatore,¹⁴⁹ A. Salvucci,¹⁰⁴ A. Salzburger,³⁰ D. Sampsonidis,¹⁵⁴ B. H. Samset,¹¹⁷ A. Sanchez,^{102a,102b} V. Sanchez Martinez,¹⁶⁷

- H. Sandaker,¹⁴ H. G. Sander,⁸¹ M. P. Sanders,⁹⁸ M. Sandhoff,¹⁷⁵ T. Sandoval,²⁸ C. Sandoval,¹⁶² R. Sandstroem,⁹⁹ D. P. C. Sankey,¹²⁹ A. Sansoni,⁴⁷ C. Santamarina Rios,⁸⁵ C. Santoni,³⁴ R. Santonico,^{133a,133b} H. Santos,^{124a} J. G. Saraiva,^{124a} T. Sarangi,¹⁷³ E. Sarkisyan-Grinbaum,⁸ F. Sarri,^{122a,122b} G. Sartisohn,¹⁷⁵ O. Sasaki,⁶⁵ Y. Sasaki,¹⁵⁵ N. Sasao,⁶⁷ I. Satsounkevitch,⁹⁰ G. Sauvage,^{5,a} E. Sauvan,⁵ J. B. Sauvan,¹¹⁵ P. Savard,^{158,c} V. Savinov,¹²³ D. O. Savu,³⁰ L. Sawyer,^{25,n} D. H. Saxon,⁵³ J. Saxon,¹²⁰ C. Sbarra,^{20a} A. Sbrizzi,^{20a,20b} D. A. Scannicchio,¹⁶³ M. Scarcella,¹⁵⁰ J. Schaarschmidt,¹¹⁵ P. Schacht,⁹⁹ D. Schaefer,¹²⁰ U. Schäfer,⁸¹ S. Schaepe,²¹ S. Schaetzel,^{58b} A. C. Schaffer,¹¹⁵ D. Schaile,⁹⁸ R. D. Schamberger,¹⁴⁸ A. G. Schamov,¹⁰⁷ V. Scharf,^{58a} V. A. Schegelsky,¹²¹ D. Scheirich,⁸⁷ M. Schernau,¹⁶³ M. I. Scherzer,³⁵ C. Schiavi,^{50a,50b} J. Schieck,⁹⁸ M. Schioppa,^{37a,37b} S. Schlenker,³⁰ E. Schmidt,⁴⁸ K. Schmieden,²¹ C. Schmitt,⁸¹ S. Schmitt,^{58b} M. Schmitz,²¹ B. Schneider,¹⁷ U. Schnoor,⁴⁴ A. Schoening,^{58b} A. L. S. Schorlemmer,⁵⁴ M. Schott,³⁰ D. Schouten,^{159a} J. Schovancova,¹²⁵ M. Schram,⁸⁵ C. Schroeder,⁸¹ N. Schroer,^{58c} M. J. Schultens,²¹ J. Schultes,¹⁷⁵ H.-C. Schultz-Coulon,^{58a} H. Schulz,¹⁶ M. Schumacher,⁴⁸ B. A. Schumm,¹³⁷ Ph. Schune,¹³⁶ C. Schwanenberger,⁸² A. Schwartzman,¹⁴³ Ph. Schwegler,⁹⁹ Ph. Schwemling,⁷⁸ R. Schwienhorst,⁸⁸ R. Schwierz,⁴⁴ J. Schwindling,¹³⁶ T. Schwindt,²¹ M. Schwoerer,⁵ G. Sciolla,²³ W. G. Scott,¹²⁹ J. Searcy,¹¹⁴ G. Sedov,⁴² E. Sedykh,¹²¹ S. C. Seidel,¹⁰³ A. Seiden,¹³⁷ F. Seifert,⁴⁴ J. M. Seixas,^{24a} G. Sekhniaidze,^{102a} S. J. Sekula,⁴⁰ K. E. Selbach,⁴⁶ D. M. Seliverstov,¹²¹ B. Sellden,^{146a} G. Sellers,⁷³ M. Seman,^{144b} N. Semprini-Cesari,^{20a,20b} C. Serfon,⁹⁸ L. Serin,¹¹⁵ L. Serkin,⁵⁴ R. Seuster,⁹⁹ H. Severini,¹¹¹ A. Sfyrlla,³⁰ E. Shabalina,⁵⁴ M. Shamim,¹¹⁴ L. Y. Shan,^{33a} J. T. Shank,²² Q. T. Shao,⁸⁶ M. Shapiro,¹⁵ P. B. Shatalov,⁹⁵ K. Shaw,^{164a,164c} D. Sherman,¹⁷⁶ P. Sherwood,⁷⁷ A. Shibata,¹⁰⁸ S. Shimizu,¹⁰¹ M. Shimojima,¹⁰⁰ T. Shin,⁵⁶ M. Shiyakova,⁶⁴ A. Shmeleva,⁹⁴ M. J. Shochet,³¹ D. Short,¹¹⁸ S. Shrestha,⁶³ E. Shulga,⁹⁶ M. A. Shupe,⁷ P. Sicho,¹²⁵ A. Sidoti,^{132a} F. Siegert,⁴⁸ Dj. Sijacki,^{13a} O. Silbert,¹⁷² J. Silva,^{124a} Y. Silver,¹⁵³ D. Silverstein,¹⁴³ S. B. Silverstein,^{146a} V. Simak,¹²⁷ O. Simard,¹³⁶ Lj. Simic,^{13a} S. Simion,¹¹⁵ E. Simioni,⁸¹ B. Simmons,⁷⁷ R. Simoniello,^{89a,89b} M. Simonyan,³⁶ P. Sinervo,¹⁵⁸ N. B. Sinev,¹¹⁴ V. Sipica,¹⁴¹ G. Siragusa,¹⁷⁴ A. Sircar,²⁵ A. N. Sisakyan,^{64,a} S. Yu. Sivoklov,⁹⁷ J. Sjölin,^{146a,146b} T. B. Sjursen,¹⁴ L. A. Skinnari,¹⁵ H. P. Skottowe,⁵⁷ K. Skovpen,¹⁰⁷ P. Skubic,¹¹¹ M. Slater,¹⁸ T. Slavicek,¹²⁷ K. Sliwa,¹⁶¹ V. Smakhtin,¹⁷² B. H. Smart,⁴⁶ L. Smestad,¹¹⁷ S. Yu. Smirnov,⁹⁶ Y. Smirnov,⁹⁶ L. N. Smirnova,⁹⁷ O. Smirnova,⁷⁹ B. C. Smith,⁵⁷ D. Smith,¹⁴³ K. M. Smith,⁵³ M. Smizanska,⁷¹ K. Smolek,¹²⁷ A. A. Snesarev,⁹⁴ S. W. Snow,⁸² J. Snow,¹¹¹ S. Snyder,²⁵ R. Sobie,^{169,l} J. Sodomka,¹²⁷ A. Soffer,¹⁵³ C. A. Solans,¹⁶⁷ M. Solar,¹²⁷ J. Solc,¹²⁷ E. Yu. Soldatov,⁹⁶ U. Soldevila,¹⁶⁷ E. Solfaroli Camillocci,^{132a,132b} A. A. Solodkov,¹²⁸ O. V. Solovyanov,¹²⁸ V. Solovyev,¹²¹ N. Soni,¹ V. Sopko,¹²⁷ B. Sopko,¹²⁷ M. Sosebee,⁸ R. Soualah,^{164a,164c} A. Soukharev,¹⁰⁷ S. Spagnolo,^{72a,72b} F. Spanò,⁷⁶ R. Spighi,^{20a} G. Spigo,³⁰ R. Spiwoks,³⁰ M. Spousta,^{126,ii} T. Spreitzer,¹⁵⁸ B. Spurlock,⁸ R. D. St. Denis,⁵³ J. Stahlman,¹²⁰ R. Stamen,^{58a} E. Stanecka,³⁹ R. W. Stanek,⁶ C. Stanescu,^{134a} M. Stanescu-Bellu,⁴² M. M. Stanitzki,⁴² S. Stapnes,¹¹⁷ E. A. Starchenko,¹²⁸ J. Stark,⁵⁵ P. Staroba,¹²⁵ P. Starovoitov,⁴² R. Staszewski,³⁹ A. Staude,⁹⁸ P. Stavina,^{144a,a} G. Steele,⁵³ P. Steinbach,⁴⁴ P. Steinberg,²⁵ I. Stekl,¹²⁷ B. Stelzer,¹⁴² H. J. Stelzer,⁸⁸ O. Stelzer-Chilton,^{159a} H. Stenzel,⁵² S. Stern,⁹⁹ G. A. Stewart,³⁰ J. A. Stillings,²¹ M. C. Stockton,⁸⁵ K. Stoerig,⁴⁸ G. Stoicea,^{26a} S. Stonjek,⁹⁹ P. Strachota,¹²⁶ A. R. Stradling,⁸ A. Straessner,⁴⁴ J. Strandberg,¹⁴⁷ S. Strandberg,^{146a,146b} A. Strandlie,¹¹⁷ M. Strang,¹⁰⁹ E. Strauss,¹⁴³ M. Strauss,¹¹¹ P. Strizenec,^{144b} R. Ströhmer,¹⁷⁴ D. M. Strom,¹¹⁴ J. A. Strong,^{76,a} R. Stroynowski,⁴⁰ J. Strube,¹²⁹ B. Stugu,¹⁴ I. Stumer,^{25,a} J. Stupak,¹⁴⁸ P. Sturm,¹⁷⁵ N. A. Styles,⁴² D. A. Soh,^{151,x} D. Su,¹⁴³ H. S. Subramania,³ A. Succurro,¹² Y. Sugaya,¹¹⁶ C. Suhr,¹⁰⁶ M. Suk,¹²⁶ V. V. Sulin,⁹⁴ S. Sultansoy,^{4d} T. Sumida,⁶⁷ X. Sun,⁵⁵ J. E. Sundermann,⁴⁸ K. Suruliz,¹³⁹ G. Susinno,^{37a,37b} M. R. Sutton,¹⁴⁹ Y. Suzuki,⁶⁵ Y. Suzuki,⁶⁶ M. Svatos,¹²⁵ S. Swedish,¹⁶⁸ I. Sykora,^{144a} T. Sykora,¹²⁶ J. Sánchez,¹⁶⁷ D. Ta,¹⁰⁵ K. Tackmann,⁴² A. Taffard,¹⁶³ R. Tafirout,^{159a} N. Taiblum,¹⁵³ Y. Takahashi,¹⁰¹ H. Takai,²⁵ R. Takashima,⁶⁸ H. Takeda,⁶⁶ T. Takeshita,¹⁴⁰ Y. Takubo,⁶⁵ M. Talby,⁸³ A. Talyshev,^{107,g} M. C. Tamssett,²⁵ J. Tanaka,¹⁵⁵ R. Tanaka,¹¹⁵ S. Tanaka,¹³¹ S. Tanaka,⁶⁵ A. J. Tanasijczuk,¹⁴² K. Tani,⁶⁶ N. Tannoury,⁸³ S. Tapprogge,⁸¹ D. Tardif,¹⁵⁸ S. Tarem,¹⁵² F. Tarrade,²⁹ G. F. Tartarelli,^{89a} P. Tas,¹²⁶ M. Tasevsky,¹²⁵ E. Tassi,^{37a,37b} M. Tatarkhanov,¹⁵ Y. Tayalati,^{135d} C. Taylor,⁷⁷ F. E. Taylor,⁹² G. N. Taylor,⁸⁶ W. Taylor,^{159b} M. Teinturier,¹¹⁵ F. A. Teischinger,³⁰ M. Teixeira Dias Castanheira,⁷⁵ P. Teixeira-Dias,⁷⁶ K. K. Temming,⁴⁸ H. Ten Kate,³⁰ P. K. Teng,¹⁵¹ S. Terada,⁶⁵ K. Terashi,¹⁵⁵ J. Terron,⁸⁰ M. Testa,⁴⁷ R. J. Teuscher,^{158,l} J. Therhaag,²¹ T. Theveneaux-Pelzer,⁷⁸ S. Thoma,⁴⁸ J. P. Thomas,¹⁸ E. N. Thompson,³⁵ P. D. Thompson,¹⁸ P. D. Thompson,¹⁵⁸ A. S. Thompson,⁵³ L. A. Thomsen,³⁶ E. Thomson,¹²⁰ M. Thomson,²⁸ W. M. Thong,⁸⁶ R. P. Thun,⁸⁷ F. Tian,³⁵ M. J. Tibbetts,¹⁵ T. Tic,¹²⁵ V. O. Tikhomirov,⁹⁴ Y. A. Tikhonov,^{107,g} S. Timoshenko,⁹⁶ P. Tipton,¹⁷⁶ S. Tisserant,⁸³ T. Todorov,⁵ S. Todorova-Nova,¹⁶¹ B. Toggerson,¹⁶³ J. Tojo,⁶⁹ S. Tokár,^{144a} K. Tokushuku,⁶⁵ K. Tollefson,⁸⁸ M. Tomoto,¹⁰¹ L. Tompkins,³¹ K. Toms,¹⁰³ A. Tonoyan,¹⁴ C. Topfel,¹⁷

N. D. Topilin,⁶⁴ I. Torchiani,³⁰ E. Torrence,¹¹⁴ H. Torres,⁷⁸ E. Torró Pastor,¹⁶⁷ J. Toth,^{83,ee} F. Touchard,⁸³ D. R. Tovey,¹³⁹ T. Trefzger,¹⁷⁴ L. Tremblet,³⁰ A. Tricoli,³⁰ I. M. Trigger,^{159a} S. Trincas-Duvoid,⁷⁸ M. F. Tripiana,⁷⁰ N. Triplett,²⁵ W. Trischuk,¹⁵⁸ B. Trocmé,⁵⁵ C. Troncon,^{89a} M. Trottier-McDonald,¹⁴² M. Trzebinski,³⁹ A. Trzupek,³⁹ C. Tsarouchas,³⁰ J. C.-L. Tseng,¹¹⁸ M. Tsiakiris,¹⁰⁵ P. V. Tsiarehska,⁹⁰ D. Tsiounou,^{5,jj} G. Tsipolitis,¹⁰ S. Tsiskaridze,¹² V. Tsiskaridze,⁴⁸ E. G. Tskhadadze,^{51a} I. I. Tsukerman,⁹⁵ V. Tsulaia,¹⁵ J.-W. Tsung,²¹ S. Tsuno,⁶⁵ D. Tsybychev,¹⁴⁸ A. Tua,¹³⁹ A. Tudorache,^{26a} V. Tudorache,^{26a} J. M. Tuggle,³¹ M. Turala,³⁹ D. Turecek,¹²⁷ I. Turk Cakir,^{4e} E. Turlay,¹⁰⁵ R. Turra,^{89a,89b} P. M. Tuts,³⁵ A. Tykhonov,⁷⁴ M. Tylmad,^{146a,146b} M. Tyndel,¹²⁹ G. Tzanakos,⁹ K. Uchida,²¹ I. Ueda,¹⁵⁵ R. Ueno,²⁹ M. Ugland,¹⁴ M. Uhlenbrock,²¹ M. Uhrmacher,⁵⁴ F. Ukegawa,¹⁶⁰ G. Unal,³⁰ A. Undrus,²⁵ G. Unel,¹⁶³ Y. Unno,⁶⁵ D. Urbaniec,³⁵ G. Usai,⁸ M. Uslenghi,^{119a,119b} L. Vacavant,⁸³ V. Vacek,¹²⁷ B. Vachon,⁸⁵ S. Vahsen,¹⁵ J. Valenta,¹²⁵ S. Valentinetti,^{20a,20b} A. Valero,¹⁶⁷ S. Valkar,¹²⁶ E. Valladolid Gallego,¹⁶⁷ S. Vallecorsa,¹⁵² J. A. Valls Ferrer,¹⁶⁷ R. Van Berg,¹²⁰ P. C. Van Der Deijl,¹⁰⁵ R. van der Geer,¹⁰⁵ H. van der Graaf,¹⁰⁵ R. Van Der Leeuw,¹⁰⁵ E. van der Poel,¹⁰⁵ D. van der Ster,³⁰ N. van Eldik,³⁰ P. van Gemmeren,⁶ I. van Vulpen,¹⁰⁵ M. Vanadia,⁹⁹ W. Vandelli,³⁰ A. Vaniachine,⁶ P. Vankov,⁴² F. Vannucci,⁷⁸ R. Vari,^{132a} T. Varol,⁸⁴ D. Varouchas,¹⁵ A. Vartapetian,⁸ K. E. Varvell,¹⁵⁰ V. I. Vassilakopoulos,⁵⁶ F. Vazeille,³⁴ T. Vazquez Schroeder,⁵⁴ G. Vegni,^{89a,89b} J. J. Veillet,¹¹⁵ F. Veloso,^{124a} R. Veness,³⁰ S. Veneziano,^{132a} A. Ventura,^{72a,72b} D. Ventura,⁸⁴ M. Venturi,⁴⁸ N. Venturi,¹⁵⁸ V. Vercesi,^{119a} M. Verducci,¹³⁸ W. Verkerke,¹⁰⁵ J. C. Vermeulen,¹⁰⁵ A. Vest,⁴⁴ M. C. Vetterli,^{142,e} I. Vichou,¹⁶⁵ T. Vickey,^{145b,kk} O. E. Vickey Boeriu,^{145b} G. H. A. Viehhauser,¹¹⁸ S. Viel,¹⁶⁸ M. Villa,^{20a,20b} M. Villaplana Perez,¹⁶⁷ E. Vilucchi,⁴⁷ M. G. Vincker,²⁹ E. Vinek,³⁰ V. B. Vinogradov,⁶⁴ M. Virchaux,^{136,a} J. Virzi,¹⁵ O. Vitells,¹⁷² M. Viti,⁴² I. Vivarelli,⁴⁸ F. Vives Vaque,³ S. Vlachos,¹⁰ D. Vladoiu,⁹⁸ M. Vlasak,¹²⁷ A. Vogel,²¹ P. Vokac,¹²⁷ G. Volpi,⁴⁷ M. Volpi,⁸⁶ G. Volpini,^{89a} H. von der Schmitt,⁹⁹ H. von Radziewski,⁴⁸ E. von Toerne,²¹ V. Vorobel,¹²⁶ V. Vorwerk,¹² M. Vos,¹⁶⁷ R. Voss,³⁰ T. T. Voss,¹⁷⁵ J. H. Vossebeld,⁷³ N. Vranjes,¹³⁶ M. Vranjes Milosavljevic,¹⁰⁵ V. Vrba,¹²⁵ M. Vreeswijk,¹⁰⁵ T. Vu Anh,⁴⁸ R. Vuillermet,³⁰ I. Vukotic,³¹ W. Wagner,¹⁷⁵ P. Wagner,¹²⁰ H. Wahlen,¹⁷⁵ S. Wahrmund,⁴⁴ J. Wakabayashi,¹⁰¹ S. Walch,⁸⁷ J. Walder,⁷¹ R. Walker,⁹⁸ W. Walkowiak,¹⁴¹ R. Wall,¹⁷⁶ P. Waller,⁷³ B. Walsh,¹⁷⁶ C. Wang,⁴⁵ H. Wang,¹⁷³ H. Wang,^{33b,ll} J. Wang,¹⁵¹ J. Wang,⁵⁵ R. Wang,¹⁰³ S. M. Wang,¹⁵¹ T. Wang,²¹ A. Warburton,⁸⁵ C. P. Ward,²⁸ M. Warsinsky,⁴⁸ A. Washbrook,⁴⁶ C. Wasicki,⁴² I. Watanabe,⁶⁶ P. M. Watkins,¹⁸ A. T. Watson,¹⁸ I. J. Watson,¹⁵⁰ M. F. Watson,¹⁸ G. Watts,¹³⁸ S. Watts,⁸² A. T. Waugh,¹⁵⁰ B. M. Waugh,⁷⁷ M. S. Weber,¹⁷ P. Weber,⁵⁴ A. R. Weidberg,¹¹⁸ P. Weigell,⁹⁹ J. Weingarten,⁵⁴ C. Weiser,⁴⁸ P. S. Wells,³⁰ T. Wenaus,²⁵ D. Wendland,¹⁶ Z. Weng,^{151,x} T. Wengler,³⁰ S. Wenig,³⁰ N. Wermes,²¹ M. Werner,⁴⁸ P. Werner,³⁰ M. Werth,¹⁶³ M. Wessels,^{58a} J. Wetter,¹⁶¹ C. Weydert,⁵⁵ K. Whalen,²⁹ S. J. Wheeler-Ellis,¹⁶³ A. White,⁸ M. J. White,⁸⁶ S. White,^{122a,122b} S. R. Whitehead,¹¹⁸ D. Whiteson,¹⁶³ D. Whittington,⁶⁰ F. Wicek,¹¹⁵ D. Wicke,¹⁷⁵ F. J. Wickens,¹²⁹ W. Wiedenmann,¹⁷³ M. Wielers,¹²⁹ P. Wienemann,²¹ C. Wigglesworth,⁷⁵ L. A. M. Wiik-Fuchs,⁴⁸ P. A. Wijeratne,⁷⁷ A. Wildauer,⁹⁹ M. A. Wildt,^{42,t} I. Wilhelm,¹²⁶ H. G. Wilkens,³⁰ J. Z. Will,⁹⁸ E. Williams,³⁵ H. H. Williams,¹²⁰ W. Willis,³⁵ S. Willocq,⁸⁴ J. A. Wilson,¹⁸ M. G. Wilson,¹⁴³ A. Wilson,⁸⁷ I. Wingerter-Seez,⁵ S. Winkelmann,⁴⁸ F. Winklmeier,³⁰ M. Wittgen,¹⁴³ S. J. Wollstadt,⁸¹ M. W. Wolter,³⁹ H. Wolters,^{124a,i} W. C. Wong,⁴¹ G. Wooden,⁸⁷ B. K. Wosiek,³⁹ J. Wotschack,³⁰ M. J. Woudstra,⁸² K. W. Wozniak,³⁹ K. Wraight,⁵³ M. Wright,⁵³ B. Wrona,⁷³ S. L. Wu,¹⁷³ X. Wu,⁴⁹ Y. Wu,^{33b,mm} E. Wulf,³⁵ B. M. Wynne,⁴⁶ S. Xella,³⁶ M. Xiao,¹³⁶ S. Xie,⁴⁸ C. Xu,^{33b,aa} D. Xu,¹³⁹ B. Yabsley,¹⁵⁰ S. Yacoub,^{145a,nn} M. Yamada,⁶⁵ H. Yamaguchi,¹⁵⁵ A. Yamamoto,⁶⁵ K. Yamamoto,⁶³ S. Yamamoto,¹⁵⁵ T. Yamamura,¹⁵⁵ T. Yamanaka,¹⁵⁵ J. Yamaoka,⁴⁵ T. Yamazaki,¹⁵⁵ Y. Yamazaki,⁶⁶ Z. Yan,²² H. Yang,⁸⁷ U. K. Yang,⁸² Y. Yang,⁶⁰ Z. Yang,^{146a,146b} S. Yanush,⁹¹ L. Yao,^{33a} Y. Yao,¹⁵ Y. Yasu,⁶⁵ G. V. Ybeles Smit,¹³⁰ J. Ye,⁴⁰ S. Ye,²⁵ M. Yilmaz,^{4c} R. Yoosoofmiya,¹²³ K. Yorita,¹⁷¹ R. Yoshida,⁶ C. Young,¹⁴³ C. J. Young,¹¹⁸ S. Youssef,²² D. Yu,²⁵ J. Yu,⁸ J. Yu,¹¹² L. Yuan,⁶⁶ A. Yurkewicz,¹⁰⁶ M. Byszewski,³⁰ B. Zabinski,³⁹ R. Zaidan,⁶² A. M. Zaitsev,¹²⁸ Z. Zajacova,³⁰ L. Zanello,^{132a,132b} D. Zanzi,⁹⁹ A. Zaytsev,²⁵ C. Zeitnitz,¹⁷⁵ M. Zeman,¹²⁵ A. Zemla,³⁹ C. Zendler,²¹ O. Zenin,¹²⁸ T. Ženiš,^{144a} Z. Zinonos,^{122a,122b} S. Zenz,¹⁵ D. Zerwas,¹¹⁵ G. Zevi della Porta,⁵⁷ Z. Zhan,^{33d} D. Zhang,^{33b,ll} H. Zhang,⁸⁸ J. Zhang,⁶ X. Zhang,^{33d} Z. Zhang,¹¹⁵ L. Zhao,¹⁰⁸ T. Zhao,¹³⁸ Z. Zhao,^{33b} A. Zhemchugov,⁶⁴ J. Zhong,¹¹⁸ B. Zhou,⁸⁷ N. Zhou,¹⁶³ Y. Zhou,¹⁵¹ C. G. Zhu,^{33d} H. Zhu,⁴² J. Zhu,⁸⁷ Y. Zhu,^{33b} X. Zhuang,⁹⁸ V. Zhuravlov,⁹⁹ D. Zieminska,⁶⁰ N. I. Zimin,²¹ R. Zimmermann,²¹ S. Zimmermann,²¹ S. Zimmermann,⁴⁸ M. Ziolkowski,¹⁴¹ R. Zitoun,⁵ L. Živković,³⁵ V. V. Zmouchko,^{128,a} G. Zobernig,¹⁷³ A. Zoccoli,^{20a,20b} M. zur Nedden,¹⁶ V. Zutshi,¹⁰⁶ and L. Zwalinski³⁰

(ATLAS Collaboration)

- ¹*School of Chemistry and Physics, University of Adelaide, Adelaide, Australia*
- ²*Physics Department, SUNY Albany, Albany, New York, USA*
- ³*Department of Physics, University of Alberta, Edmonton, Alberta, Canada*
- ^{4a}*Department of Physics, Ankara University, Ankara, Turkey*
- ^{4b}*Department of Physics, Dumlupinar University, Kutahya, Turkey*
- ^{4c}*Department of Physics, Gazi University, Ankara, Turkey*
- ^{4d}*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
- ^{4e}*Turkish Atomic Energy Authority, Ankara, Turkey*
- ⁵*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
- ⁶*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
- ⁷*Department of Physics, University of Arizona, Tucson, Arizona, USA*
- ⁸*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
- ⁹*Physics Department, University of Athens, Athens, Greece*
- ¹⁰*Physics Department, National Technical University of Athens, Zografou, Greece*
- ¹¹*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
- ¹²*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain*
- ^{13a}*Institute of Physics, University of Belgrade, Belgrade, Serbia*
- ^{13b}*Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*
- ¹⁴*Department for Physics and Technology, University of Bergen, Bergen, Norway*
- ¹⁵*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
- ¹⁶*Department of Physics, Humboldt University, Berlin, Germany*
- ¹⁷*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
- ¹⁸*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
- ^{19a}*Department of Physics, Bogazici University, Istanbul, Turkey*
- ^{19b}*Division of Physics, Dogus University, Istanbul, Turkey*
- ^{19c}*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
- ^{19d}*Department of Physics, Istanbul Technical University, Istanbul, Turkey*
- ^{20a}*INFN Sezione di Bologna, Italy*
- ^{20b}*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
- ²¹*Physikalisches Institut, University of Bonn, Bonn, Germany*
- ²²*Department of Physics, Boston University, Boston, Massachusetts, USA*
- ²³*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
- ^{24a}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
- ^{24b}*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
- ^{24c}*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
- ^{24d}*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*
- ²⁵*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
- ^{26a}*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
- ^{26b}*University Politehnica Bucharest, Bucharest, Romania*
- ^{26c}*West University in Timisoara, Timisoara, Romania*
- ²⁷*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
- ²⁸*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
- ²⁹*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
- ³⁰*CERN, Geneva, Switzerland*
- ³¹*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
- ^{32a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
- ^{32b}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
- ^{33a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
- ^{33b}*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
- ^{33c}*Department of Physics, Nanjing University, Jiangsu, China*
- ^{33d}*School of Physics, Shandong University, Shandong, China*
- ³⁴*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France*
- ³⁵*Nevis Laboratory, Columbia University, Irvington, New York, USA*
- ³⁶*Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark*
- ^{37a}*INFN Gruppo Collegato di Cosenza, Italy*
- ^{37b}*Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy*
- ³⁸*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
- ³⁹*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
- ⁴⁰*Physics Department, Southern Methodist University, Dallas, Texas, USA*

- ⁴¹*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
- ⁴²*DESY, Hamburg and Zeuthen, Germany*
- ⁴³*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
- ⁴⁴*Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany*
- ⁴⁵*Department of Physics, Duke University, Durham, North Carolina, USA*
- ⁴⁶*SUPA-School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁴⁷*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
- ⁴⁸*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany*
- ⁴⁹*Section de Physique, Université de Genève, Geneva, Switzerland*
- ^{50a}*INFN Sezione di Genova, Italy*
- ^{50b}*Dipartimento di Fisica, Università di Genova, Genova, Italy*
- ^{51a}*E. Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi, Georgia*
- ^{51b}*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
- ⁵²*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
- ⁵³*SUPA-School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁵⁴*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
- ⁵⁵*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
- ⁵⁶*Department of Physics, Hampton University, Hampton, Virginia, USA*
- ⁵⁷*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
- ^{58a}*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58b}*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58c}*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
- ⁵⁹*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
- ⁶⁰*Department of Physics, Indiana University, Bloomington, Indiana, USA*
- ⁶¹*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
- ⁶²*University of Iowa, Iowa City, Iowa, USA*
- ⁶³*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
- ⁶⁴*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
- ⁶⁵*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
- ⁶⁶*Graduate School of Science, Kobe University, Kobe, Japan*
- ⁶⁷*Faculty of Science, Kyoto University, Kyoto, Japan*
- ⁶⁸*Kyoto University of Education, Kyoto, Japan*
- ⁶⁹*Department of Physics, Kyushu University, Fukuoka, Japan*
- ⁷⁰*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
- ⁷¹*Physics Department, Lancaster University, Lancaster, United Kingdom*
- ^{72a}*INFN Sezione di Lecce, Italy*
- ^{72b}*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
- ⁷³*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
- ⁷⁴*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
- ⁷⁵*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
- ⁷⁶*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
- ⁷⁷*Department of Physics and Astronomy, University College London, London, United Kingdom*
- ⁷⁸*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
- ⁷⁹*Fysiska institutionen, Lunds universitet, Lund, Sweden*
- ⁸⁰*Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain*
- ⁸¹*Institut für Physik, Universität Mainz, Mainz, Germany*
- ⁸²*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
- ⁸³*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
- ⁸⁴*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
- ⁸⁵*Department of Physics, McGill University, Montreal, Quebec City, Canada*
- ⁸⁶*School of Physics, University of Melbourne, Victoria, Australia*
- ⁸⁷*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
- ⁸⁸*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
- ^{89a}*INFN Sezione di Milano, Italy*
- ^{89b}*Dipartimento di Fisica, Università di Milano, Milano, Italy*
- ⁹⁰*B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
- ⁹¹*National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus*
- ⁹²*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
- ⁹³*Group of Particle Physics, University of Montreal, Montreal, Quebec City, Canada*
- ⁹⁴*P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*

- ⁹⁵*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
⁹⁶*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
⁹⁷*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
⁹⁸*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
⁹⁹*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
¹⁰⁰*Nagasaki Institute of Applied Science, Nagasaki, Japan*
¹⁰¹*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
^{102a}*INFN Sezione di Napoli, Italy*
^{102b}*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
¹⁰³*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
¹⁰⁴*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
¹⁰⁵*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
¹⁰⁶*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
¹⁰⁷*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
¹⁰⁸*Department of Physics, New York University, New York, New York, USA*
¹⁰⁹*Ohio State University, Columbus, Ohio, USA*
¹¹⁰*Faculty of Science, Okayama University, Okayama, Japan*
¹¹¹*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
¹¹²*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
¹¹³*Palacký University, RCPTM, Olomouc, Czech Republic*
¹¹⁴*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
¹¹⁵*LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France*
¹¹⁶*Graduate School of Science, Osaka University, Osaka, Japan*
¹¹⁷*Department of Physics, University of Oslo, Oslo, Norway*
¹¹⁸*Department of Physics, Oxford University, Oxford, United Kingdom*
^{119a}*INFN Sezione di Pavia, Italy*
^{119b}*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
¹²⁰*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
¹²¹*Petersburg Nuclear Physics Institute, Gatchina, Russia*
^{122a}*INFN Sezione di Pisa, Italy*
^{122b}*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
¹²³*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
^{124a}*Laboratorio de Instrumentacao e Fisica Experimental de Particulas-LIP, Lisboa, Portugal*
^{124b}*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
¹²⁵*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
¹²⁶*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
¹²⁷*Czech Technical University in Prague, Praha, Czech Republic*
¹²⁸*State Research Center Institute for High Energy Physics, Protvino, Russia*
¹²⁹*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
¹³⁰*Physics Department, University of Regina, Regina, Saskatchewan, Canada*
¹³¹*Ritsumeikan University, Kusatsu, Shiga, Japan*
^{132a}*INFN Sezione di Roma I, Italy*
^{132b}*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
^{133a}*INFN Sezione di Roma Tor Vergata, Italy*
^{133b}*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
^{134a}*INFN Sezione di Roma Tre, Italy*
^{134b}*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
^{135a}*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies-Université Hassan II, Casablanca, Morocco*
^{135b}*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
^{135c}*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
^{135d}*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
^{135e}*Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco*
¹³⁶*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France*
¹³⁷*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
¹³⁸*Department of Physics, University of Washington, Seattle, Washington, USA*
¹³⁹*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
¹⁴⁰*Department of Physics, Shinshu University, Nagano, Japan*
¹⁴¹*Fachbereich Physik, Universität Siegen, Siegen, Germany*
¹⁴²*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*

- ¹⁴³SLAC National Accelerator Laboratory, Stanford, California, USA
- ^{144a}Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic
- ^{144b}Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
- ^{145a}Department of Physics, University of Johannesburg, Johannesburg, South Africa
- ^{145b}School of Physics, University of the Witwatersrand, Johannesburg, South Africa
- ^{146a}Department of Physics, Stockholm University, Sweden
- ^{146b}The Oskar Klein Centre, Stockholm, Sweden
- ¹⁴⁷Physics Department, Royal Institute of Technology, Stockholm, Sweden
- ¹⁴⁸Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA
- ¹⁴⁹Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
- ¹⁵⁰School of Physics, University of Sydney, Sydney, Australia
- ¹⁵¹Institute of Physics, Academia Sinica, Taipei, Taiwan
- ¹⁵²Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel
- ¹⁵³Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
- ¹⁵⁴Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
- ¹⁵⁵International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
- ¹⁵⁶Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
- ¹⁵⁷Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
- ¹⁵⁸Department of Physics, University of Toronto, Toronto, Ontario, Canada
- ^{159a}TRIUMF, Vancouver, British Columbia, Canada
- ^{159b}Department of Physics and Astronomy, York University, Toronto, Ontario, Canada
- ¹⁶⁰Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan
- ¹⁶¹Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA
- ¹⁶²Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
- ¹⁶³Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA
- ^{164a}INFN Gruppo Collegato di Udine, Italy
- ^{164b}ICTP, Trieste, Italy
- ^{164c}Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy
- ¹⁶⁵Department of Physics, University of Illinois, Urbana, Illinois, USA
- ¹⁶⁶Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
- ¹⁶⁷Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain
- ¹⁶⁸Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada
- ¹⁶⁹Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada
- ¹⁷⁰Department of Physics, University of Warwick, Coventry, United Kingdom
- ¹⁷¹Waseda University, Tokyo, Japan
- ¹⁷²Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel
- ¹⁷³Department of Physics, University of Wisconsin, Madison, Wisconsin, USA
- ¹⁷⁴Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany
- ¹⁷⁵Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany
- ¹⁷⁶Department of Physics, Yale University, New Haven, Connecticut, USA
- ¹⁷⁷Yerevan Physics Institute, Yerevan, Armenia
- ¹⁷⁸Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France

^aDeceased.

^bAlso at Laboratório de Instrumentação e Física Experimental de Partículas-LIP, Lisboa, Portugal.

^cAlso at Faculdade de Ciências and CFNUL, Universidade de Lisboa, Lisboa, Portugal.

^dAlso at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.

^eAlso at TRIUMF, Vancouver, BC, Canada.

^fAlso at Department of Physics, California State University, Fresno, CA, USA.

^gAlso at Novosibirsk State University, Novosibirsk, Russia.

^hAlso at Fermilab, Batavia, IL, USA.

ⁱAlso at Department of Physics, University of Coimbra, Coimbra, Portugal.

^jAlso at Department of Physics, UASLP, San Luis Potosi, Mexico.

^kAlso at Università di Napoli Parthenope, Napoli, Italy.

^lAlso at Institute of Particle Physics (IPP), Canada.

^mAlso at Department of Physics, Middle East Technical University, Ankara, Turkey.

ⁿAlso at Louisiana Tech University, Ruston, LA, USA.

^oAlso at Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal.

^pAlso at Department of Physics and Astronomy, University College London, London, United Kingdom.

^qAlso at Group of Particle Physics, University of Montreal, Montreal, QC, Canada.

^rAlso at Department of Physics, University of Cape Town, Cape Town, South Africa.

^sAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.

^tAlso at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.

^uAlso at Manhattan College, New York, NY, USA.

^vAlso at School of Physics, Shandong University, Shandong, China.

^wAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.

^xAlso at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.

^yAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.

^zAlso at Dipartimento di Fisica, Università La Sapienza, Roma, Italy.

^{aa}Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France.

^{bb}Also at Section de Physique, Université de Genève, Geneva, Switzerland.

^{cc}Also at Departamento de Fisica, Universidade de Minho, Braga, Portugal.

^{dd}Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.

^{ee}Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.

^{ff}Also at California Institute of Technology, Pasadena, CA, USA.

^{gg}Also at Institute of Physics, Jagiellonian University, Krakow, Poland.

^{hh}Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.

ⁱⁱAlso at Nevis Laboratory, Columbia University, Irvington, NY, USA.

^{jj}Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.

^{kk}Also at Department of Physics, Oxford University, Oxford, United Kingdom.

^{ll}Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.

^{mm}Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.

ⁿⁿAlso at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa.